PSYCHOLOGY OF ANTS
AND OF
HIGHER ANIMALS

REV. E. WASMANN S. J.

COMPARATIVE STUDIES

IN THE

Psychology of Ants and of Higher Animals.

BY

ERIC WASMANN, S. J.

Plus enim formicularum et apicularum opera stupemus quam immensa corpora balaenarum,
(*S. Augustine, De Civit, Dei, l.* 22, *c.* 24, *n.* 5.)

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PREFACE TO THE FIRST EDITION.

SOME time ago we published an essay entitled "Instinct and Intelligence in the Animal Kingdom," examining in detail the concepts of *instinct* and *intelligence,* with their application to animals. The discussion showed that *intelligence* is the spiritual power of abstraction, and not the mere faculty of forming complex sense-representations; for the laws of association in sense-perceptions belong to the sphere of instinctive sensitive life and not to spiritual intelligence. Now, what modern animal psychology terms "intelligence of animals," is nothing but inborn instinct, raised to a higher level of perfection by the individual's sensuous experience. This, in its turn, is based on the very same laws of association of sense-representations. Hence, there is no reason for ascribing to animals *intelligence in the strict sense.* Indeed, our reasoning led us to take a further step, and we proved that *animals have no intelligence at all.* If they were gifted with a spiritual power of abstraction, it would necessarily be manifested in their *outward* actions, especially by the formation of an arbitrary phonetic or graphic language. Animals, however, have no language; hence, they have no intelligence.

Besides, we have shown in the same essay that the manifestations of the psychic life, both of higher and of lower animals, are to be judged according to *one and the same critical standard.* The anatomical

difference, that exists between the sense organs and the nervous system of Arthropods on the one hand and of Vertebrates on the other, is not a sufficient *a priori* reason for ascribing intelligence to the latter only and denying it to the former. The proof of these assertions forms the groundwork of the present essay. We shall compare more at length the psychic life of the most "intelligent" Arthropods, namely the ants, with that of the higher Vertebrates and of man. From this discussion we shall learn, whether the "missing link," with which modern evolutionists hope to bridge over the chasm between the instinct of animals and the spiritual soul of man, is to be looked for in ants or in the higher Vertebrates, or whether, in fact, it exists at all. Biologists will be pleased to find that the present essay contains many new observations on the habits of ants and their guests.

PREFACE TO THE SECOND EDITION.

THE numerous observations of modern scientists, illustrating the relations between the psychic life of ants and of higher animals, have been extensively utilized in preparing this second edition. We have paid due regard to the observations and experiments, published since 1897, on the differentiation of castes in bee-hives. Besides, we have turned to account the results of a statistical chart now completed, extending over five years and comprising all the colonies of *Formica sanguinea* in the neighborhood of Exaten, Holland. This ant is the most interesting of all European species. Thus we are able to publish many new facts of interest in scientific biology regarding the slave-making habits of this ant, its methods of nest construction, its relationship to its guest *Lomechusa*, and the influence of the latter in the differentiation of castes in ant communities. Finally, two additional illustrations of *Lomechusa strumosa* and of its larva have been added in the text.

TRANSLATOR'S PREFACE.

WASMANN'S "Instinct and Intelligence in the Animal Kingdom," which appeared recently in an English dress (Herder, St. Louis, Mo.), was so favorably received, that it has been thought advisable to follow it up with this translation of another essay by the same author. These two books supplement each other, as may be gathered from the frequent cross references they contain, and, more especially, from the close relationship of the subjects of which they treat.

The best recommendation of Wasmann's biological and psychological essays is given in the following lines of *W. M. Wheeler*, Prof. of the University of Texas:[1] "Wasmann in his numerous writings has undoubtedly done much, at least in Germany, towards the exposure of this pseudo-psychology (of Brehm, Buechner and others) and a more rational conception of ant behavior. His long familiarity with these animals and their guests has given him a singularly lucid insight into their activities. My own more limited observations on our North American species lead me to agree with him so far as the facts are concerned, and many of the inferences which he has drawn from them." As to his additional remark: "I am constrained to say, however, that I cannot adopt

[1]) "The Compound and Mixed Nests of American Ants," in "American Naturalist," Vol. XXV, 1901, p. 808.

either his psychological definitions or his psychogenetic reservations,"—we call the critic's attention to the end of the fourth chapter of "Instinct and Intelligence in the Animal Kingdom," where Prof. Wheeler's objections have been answered.

In order to make the English translation more valuable for North America, the author has kindly added a series of notes and observations on the ant fauna of the United States. He has added, moreover, the figures representing the North American form of *Formica sanguinea* and that of its guest *Xenodusa cava*. The present work, therefore, is more than a translation; it may be called a new edition, revised and enlarged by Father Wasmann.

Canisius College, Buffalo, N. Y.

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INTRODUCTION.

EVEN in ancient times, observers of animal life noticed that bodily size and psychic perfection are not always in direct proportion, but that the reverse is not unfrequently the case. Thus Aristotle[1] declared that keenness of perception (*τὴν τῆς διανοίας ἀκρίβειαν*) was often more manifest in smaller than in larger animals. Nor did it escape the great Stagirite, who was not only a logical thinker, but also a skilful observer, that many animals of low rank in the zoological scale were endowed, in some way, with a higher psychic life than the highest mammals, so much so, that its manifestations could be compared with human institutions only. He mentions, especially, ants and bees among those "bloodless" animals which possess a more intellectual soul than many animals of the other kind.[2] The same thought was expressed by St. Augustine, one of the loftiest Christian minds, in the following terms: "We admire the works of the tiny ants and bees more than the bulky forms of whales."[3] And a distinguished modern naturalist, Emil Dubois-Reymond, has acknowledged

[1]) *"Hist. animal.,"* l. 9, c. 7 (Becker I, 612).

[2]) *"De partib. animal.,"* l. 2, c. 4 (Becker I, 650). Aristotle's division of animals into those with *red* blood and those with *colorless* blood in reality coincides with that of Vertebrates and Non-Vertebrates. He uses the term "Bloodless Animals" for those which have no *red* blood.

[3]) *"De civ. Dei,"* l. 22, c. 24, n. 5 (Migne XLI, 792).

in the name of his colleagues:[1] "With reverential awe does he (the naturalist) gaze at the microscopic speck of nervous substance, which harbors the soul of the ant with its industry, its instincts of architecture, order, fidelity and courage."

Surely, it was not without great reason that scientific observers of recent times applied themselves to the most careful and detailed examination of the life of ants, especially since the publication of Pierre Huber's classical *"Recherches sur les Moeurs des Fourmis indigènes"* (1810). Very many interesting facts of great value for psychological research have thus been furnished. However, dabblers in popular science, who viewed things from the standpoint of "vulgar psychology," as Wundt termed it, misinterpreted these facts in a very unscientific manner; for they tried to draw conclusions from them which led to the humanization of animals, and denied the existence of any essential difference between the psychic faculties of man and brute. It is not so very long since Ludwig Buechner endeavored to promote these ideas in his *"Geistesleben der Tiere"* (Berlin, 1876). As is generally the case with such shallow elaborations, Buechner has found not a few imitators and plagiarists. Therefore, it may not be out of place to examine these deductions from the standpoint of critical psychology.

Sir John Lubbock, who devoted himself to the study of ant life with the accuracy of a professional scientist, and who carefully refrained from the

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[1]) "Ueber die Grenzen des Naturerkennens." Lectures by E. Dubois-Reymond, 1st issue (Leipzig, 1886), p. 127.

humanizing tendencies of modern times, states in the introduction to his book, "Ants, Wasps and Bees," that ants rank next to man in the scale of intelligence, and that in psychic faculties they approach nearer to man than the Anthropoid apes even. George Romanes in the sixth edition of his book, "Animal Intelligence" (1895), devotes more than one hundred pages to ants, and thus indicates the great importance he ascribes to their psychic qualities.

Prior to Lubbock's work on ants, another prominent investigator of ant life, Dr. Augustus Forel, in his "*Fourmis de la Suisse*" (1874) had expressed the opinion that the principal factor in the psychic activity of ants was not individual intelligence, but social instincts (p. 444). Although he pretends to find even among ants remarkable proofs of intellect, he maintains that it cannot compare with the individual intelligence of the higher Vertebrates (as apes, seals, elephants, etc.). Most of my critics, likewise, especially Forel and Smalian, in discussing my book "The Compound Nests and Mixed Colonies of Ants," conceded that ants were guided in their life and doings almost exclusively by their social instincts. With the higher Vertebrates, however, intelligence is said to preponderate gradually over instinct. This is postulated by Darwin's theory of evolution, which otherwise would be unable to explain the mental evolution of man from the animal kingdom. The only possible explanation according to this theory is to assume that, to the individual mammal-intelligence of the hypothetical ancestors of man, there was added, through the development of community life, a higher

degree of perfection in their social instincts, and that thereby the higher animal was gradually transformed into man.

The tenability of this assumption will be discussed in the following chapters. It is understood, that in our comparative investigation, we shall be guided, not by the postulates of evolutionist theories, but by the principles of critical psychology, set forth at length in our former essay, "Instinct and Intelligence in the Animal Kingdom" (Herder, St. Louis, Mo., 1903).

Lately there has been invented a theory on the psychic life of ants, which is diametrically opposed to the popular attempts at humanization. Alb. Bethe[1] has tried to set down ants and bees as mere "reflex machines," devoid even of the simplest sensitive perception and cognition, whilst he considers the intelligence of higher animals to be beyond all doubt. Thus he hoped to succeed in destroying the parallelism established by us between the psychic faculties of ants and those of higher animals, from which we had drawn the conclusion: we do not need ant intelligence, therefore neither animal intelligence. Bethe's work is of undoubted value on account of its attack on the still wide-spread popular views regarding ants as intelligent, human beings in miniature.[2] His theory has

[1] "Duerfen wir den Ameisen und Bienen psychische Qualitaeten zuschreiben?" Bonn, 1898. ("Archiv fuer die gesamte Physiologie," LXX, 15-100.)

[2] In this regard the "Betrachtungen ueber die staatlich lebenden Immen," published against Bethe's essay by Charles Sajó in "Prometheus" (10 Jahrg., 1899, Nr. 486 and 487), go far beyond what is admissible. Similarly the essay by Kienitz-Gerloff, "Besitzen die Ameisen Intelligenz?" in "Naturwissenschaftl. Wochenschrift" (XIV, 1899, n. 20 and 21).

already, on another occasion,[1] been subjected by us to a thorough discussion. Besides, in a longer essay, especially intended for professional zoologists,[2] we have since then perfected our former argument, proving that ants are no more mere reflex machines than dogs and apes are intelligent beings. The theoretical side of Bethe's psychological views was also noticed in the second edition of our essay "Instinct and Intelligence in the Animal Kingdom" (chapters 7 and 8).[3] In this work, therefore, we shall return to them but occasionally, to show the fatal results of attempting to vindicate the intelligence of higher animals by completely denying psychic activities in ants.

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[1]) "A new reflex theory of ant life" (Biolog. Centralbl., XVIII, 1898, n. 15, p. 577-588).

[2]) "Die psychischen Faehigkeiten der Ameisen." Stuttgart, 1899. ("Zoologica," Heft 26) p. 134 and foll. with 3 plates.

[3]) p. 144 and following.

CHAPTER I.

COMMUNITY LIFE IN THE ANIMAL KINGDOM.

1. *A General Survey of the Forms of Animal Communities.*

THE multiplicity of bodily shapes apparent in animals is not more remarkable than the variety found in their biological relations. The majority of animals, lower as well as higher, live singly, and only temporarily join other individuals of the same species for breeding purposes; no lasting psychic tie unites them with others of their species. Other animals live in pairs during the breeding season, and remain united until the young are old enough to shift for themselves; this is the case with most birds and mammals. If the offspring continue to remain with their parents, families develop into herds, embracing the members of different, allied families. Thus, v. g., wild oxen and horses, the chamois, antelopes and many apes are gregarious animals. While real gregariousness is based on family ties in a wider sense and is mostly permanent, other animals flock together to form troops or hordes to undertake journeys in common, e. g., our migratory birds in autumn, the Scandinavian lemmings, etc. Insects, too, gather into similar temporary masses of individuals of the same or closely allied species, assuming the form of migrating swarms. Migrating locusts are known to everybody; but also

butterflies, dragon-flies and other insects have been observed to form similar swarms.

But few animal species are so perfect in their social organization, that the members of the family construct their habitations, rear their offspring and provide for their food in common. These are what Aristotle calls **Ζῶα πολιτικά**, animals leading a *well regulated social life*, comparable, in a way, to the social life of man. These animals are chiefly the so-called *state-forming insects*, the social wasps, bees, ants and termites. With the two latter social life is carried to the highest degree of perfection found in the whole animal kingdom. True, also among birds, the social weavers (*Ploceus*) construct habitations in common, inasmuch as they build their nests close together, and beavers unite in colonies to build their dams, when different pairs are interested in raising the water level at the same spot. But what is wanting in the associations of higher animals is co-operation, including some suitable division of labor for the rearing and nourishing of their offspring. The *combination* of all these elements of social life is found only among the social insects, and in a prominent degree among *ants*.

Viewed from the standpoint of comparative psychology, social is preferable by far to single life. In this connection, of course, we mean a social life based on *social instincts*, on the laws of *sensitive cognition*, and not merely a union caused by the laws of *vegetative life*, as is the case with certain *animal conglomerates*, as sponges, corals, polyps and many species of Tunicates. The bond, which unites the different individuals of these species to a colony, is entirely material. They

live together from immediate, vegetative necessity; for they literally grow as branches from a common trunk. As it is an immediate vegetative necessity for plants to bring forth twigs, leaves and blossoms, so *mere vegetative* necessity forces a colony of Siphonophores to separate into different loosely connected individuals, some serving the purpose of nutrition (nutrient polyps), others of propagation (sexual polyps), of perception (perception polyps), of locomotion (swimming polyps), and of protection (protective polyps). To apply to the members of such colonies the term "persons" (eating persons, swimming persons, etc.), as Haeckel and several other zoologists have done, is evidently out of place, because this term implies a psychic independence which these animals do not possess. It would be more justifiable to conceive the whole growth of Siphonophores as *one* individual of imperfect unity, consisting of various members, which, on account of their different functions can more fitly be termed "organs" than "persons."

The similarity of social life in the colonies of polyps and of ants is very slight and superficial. The latter, in opposition to the former, consists of individuals organically separated and independent in their psychic activities. The members of an ant colony are complete individuals united to each other, not by the *laws of vegetative growth,* but by *instinctive sympathy.* This kind of co-habitation must indeed be regarded as a higher manifestation of psychic life unknown among solitary animals.

It is true, with the state-forming insects also, the instinctive association of the individuals of a colony

is based on an *organic*, i. e., *vegetative* fact, namely on the common descent from one and the same parent, called a "queen."

Honey-bees have never more than *one* queen in the hive, ants may have *several* of them. The instinctive dependence of bees on their queen is not so great as was formerly believed. Moreover, in the bee-hive the queen has essentially no other function than that of laying eggs; for the rest, her attitude towards the social activities of the colony is entirely passive; even when the bees are swarming the old "sovereign" is generally hurried along by the crowd of her "faithful subjects;" she does not lead the expedition, neither does she determine its direction.[1] However, a swarm of bees deprived of their queen will disperse, because they have no common center of attraction, no point of crystallization, so to say, around which to form a new colony. In bee-hives the instinctive bond uniting queen and workers is closer than among ants, because the odor emitted by the queen exercises a far more powerful attraction[2] on the workers than in the case

[1]) Abbé J. J. Kieffer communicated the following observations: "An old queen must often be actually forced out of the hive by the bees already swarming; sometimes the bees are gone, the queen being left behind in the hive. In other cases I observed that the old queen had dropped to the ground; in spite of this, the bees settled at quite a different place on some tree, and suffered themselves to be put in a new hive which, however, they soon left again, because the queen was missing."

[2]) How powerful is this attraction, can be gathered from an observation made by Fr. Spillmann, S. J., in June, 1896. On catching a cluster of swarming bees, a few hundred workers had remained in the catching apparatus and could not find their way to the new hive. Led by their sense of smell, however, they clustered around a queen that had been lying dead on the ground for eight days, although it belonged to a different hive.

of ants. Thus the queen of the bee-hive becomes in a higher degree the *principle of union* for the workers of her colony and for the regulated exercise of their instincts. For this very reason but one full-grown queen is tolerated in a bee-hive, while in ant nests *several* may be found. What follows may ultimately account for the fact.

The workers among ants live much longer than among bees. According to my observations, our *Formica* species, as a rule, attain an age of two, sometimes of three years, whilst the workers among bees die after a few weeks or months. For this reason a colony of ants can continue to exist for several years without a queen, and even produce males through parthenogenesis. This longer duration of life with workers among ants may perhaps explain, why they are less dependent on their queen than bees, and fairly accounts for the fact, that, with ants, queens are needed as *the unitive principle* of the colony in a far inferior degree. Hence in a community of ants the number of generating, impregnated females may be almost unlimited. In a populous nest of the hill-ant (*Formica rufa*) near Exaten (Holland), I once found more than sixty full-grown queens. A similar number I met with in a nest of the small, red stinging ant (*Myrmica scabrinodis*). In fact, by far the greater part of European ant species have, as a rule, several queens in every colony of long standing. With foreign ants the case is pretty much the same.

A community of bees, therefore, having only *one queen*, may aptly be compared with a *monarchy*. But on account of the great number of oviparous mem-

bers and the consequent greater independence of instincts in the single worker, an ant colony bears the stamp rather of *democratic, republican, even socialistic* institutions. Viewed from the standpoint of comparative psychology, the community life of ants is more perfect than that of bees, on account of the greater *psychic independence* of each individual. It is this quality of individual independence that lends to ant-states, among all associations of animals, the *greatest resemblance* to the *political societies of man* based on individual intelligence and free will. This resemblance is of course never more than *mere analogy*; but it is the *highest degree* of analogy known to exist between the social institutions of man and of the brute. Nor is the term "state" applicable to the social organizations of ants or, in fact, to any animal community, in any other than a *metaphorical* meaning; yet it applies more perfectly to ant states than to any other family of insects, and to insect states rather than to those of any other animals.

Another important reason, why with ant colonies the use of the term "state" is comparatively more appropriate than with the social organizations of other animals is, because colonies of ants are often not merely "enlarged families," but contain also members of *entirely different species* which are hospitably sheltered in the colony. Thus a *simple* ant colony comes to be a *compound* animal society. The above-mentioned strangers are partly ants belonging to other

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[2] On this point vide A. Espinas, "Des sociétés animales" (2e éd.) p. 472. Also Karl E. v. Baer (in Stoelzle, "K. E. v. Baer und seine Weltanschauung" [1901], p. 300); W. Wundt, "Vorlesungen ueber die Menschen- und Tierseele," 2d ed., p. 451.

species,[1] living in the colony as "auxiliaries" or "slaves"; partly they are members of altogether different orders of insects, especially of certain beetles, as the genera *Atemeles* and *Lomechusa,* which are accorded a friendly reception by the ants, are licked and fed, their larvae being reared by the ants as if they were the latters' own.[2] This is a special form of community life (*symbiosis*), found nowhere else throughout the animal kingdom. Symbiosis is only equal to real community life, when the members engage in mutual *psychic intercourse.* Between a hermit crab and a sea anemone that settles on the former's back, between a small fish (*Trachichthys tunicatus*) and a large sea nettle harboring it within the circle of its tentacles,[3] there is a mutual relation (mutualism) useful to both of them, without, however, approaching any psychic intercourse, although the one instinctively looks for the other. There is a similar relation between ants and many of their tolerated guests, whilst their relation to their slaves and to their genuine guests attains a higher degree of psychological intercourse and becomes real *community life.* Moreover, parasites, hostile intruders and indifferently

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[1]) See Wasmann, "Die zusammengesetzten Nester und gemischten Kolonien der Ameisen," part II.

[2]) See the "Autobiography of a *Lomechusa,*" in "Stimmen aus Maria Laach," LII (1897), 69, where the literature of the subject is enumerated. The number of the regular nestmates of ants and termites is rather considerable. Our "Kritisches Verzeichnis der myrmekophilen und termitophilen Arthropoden," published in 1894, already contains 1,246 ant guests and 109 termite guests, having the most various biological relations to their hosts. Since then many new species from all quarters of the world have been discovered and described.

[3]) See "Zool. Anzeiger," Vol. XI (1888), n. 278, p. 240.

tolerated cohabitants are found in the society of many higher and lower animals. They are present likewise in the nests of social wasps, hornets and bumblebees; but genuine guests (Symphiles), which, in spite of their morphological difference, are treated by their hosts as enjoying equal rights, as members of the family, are met with only among ants and termites. That stray chamois or steinbocks should join a herd of goats, is evidently something quite different from the fact that ants keep aphides and scale-insects as their milk cows, and tend even their eggs; or that they feed from their own mouths certain species of beetles, which on being licked afford the ants a special pleasurable sensation, herein treating them the same as they do their own comrades and larvae. The mutual social relationship which is here seen to exist between the animals of different species, and which we term Symphily (σύν-φιλία) is by far more perfect. Although, as we shall show later on, it is intimately connected with the instinct of adoption which occurs also among higher animals, the relation existing between ants on the one hand and their slaves and genuine guests on the other, is nevertheless a form of perfect Symbiosis unparalleled among the Vertebrates.

2. *The Social Basis of Ant States.*

As was already indicated, the ultimate foundation of ant states is *organic*. It is organic, not only because it is due to the descent from a common oviparous female, but more especially because it is conditioned, in its essential outlines, by *polymorphism,*

in other words, by bodily difference in the individuals of a colony. Ant states are organically divided into fixed groups of different "*castes,*" possessing different corporal and psychic qualities. These castes take their origin from the peculiar organic development of ants; they depend on *laws of vegative growth,* not on the intelligence and free will of individuals, as do the classes of human society. By far the majority of members of ant colonies consist, of course, of wingless neuters, which go by the name of "workers" or simply "ants." These workers are a secondary form of the female, the ovaries being stunted, while brain and instincts are all the more highly developed.[1] With many ants, especially with the genera *Pheidole, Pheidologeton, Eciton, Colobopsis,* etc., the workers are again divided into two more or less strictly separated castes differing in bodily structure, namely workers proper and soldiers, the latter possessing a comparatively huge head and formidable jaws. The wingless workers and soldiers are entrusted with the colony's social welfare; it is their duty to build the nest, to tend the young, to gather provisions and to defend the community against hostile invaders, whilst the winged males and females attend to the propagation of the species. After having been fertilized, which is generally done in the air during their nuptial flight, the females lose their wings and become "queens," either founding new colonies or being taken back by workers into their old nest for oviposition.

The *basis,* therefore, of the so-called political con-

[1]) Hence they cannot be simply called "stunted females," no more than the workers among bees.

stitution of ants[1] is in fact *organic;* it consists in the descent from one fertile female, and in the differentiation of the descendants into castes differing in bodily and psychic qualities, as a result of the very same specific fertility. The *social bond,* however, which unites the members of an ant colony and separates them from other colonies of the same species, is *psychic and instinctive.* It is the *feeling of fellowship,* the *instinct of sociality,* resulting from common descent; it is, moreover, the *instinct of imitation* which urges the workers of the same colony to act in concert. This unity and co-operation is effected by means of a certain *sensile feeler language*: by a touch of their feelers thousands of members of a colony immediately recognize one another as belonging to the same community and effectually discover the intruder; by taps of their antennae they exchange their feelings and perceptions and thus draw the attention of other workers of their colony to the same work. The same feeler language is also the means of communication of ants in mixed colonies with their auxiliaries of other species, and of genuine ant guests with their hosts.

This distinction between members of their own colony and those of others is effected by very delicate *organs of smell*[2] situated in the antennae. Members

[1]) We mean here in the first place the ***simple*** ant societies which embrace no members of different species.

[2]) We have already proven in our work, "Die psychischen Faehigkeiten der Ameisen" ("Zoologica," 26th issue, p. 10-16), that there is not merely question of a "chemical reflex" (as Bethe calls it), but of a real sensitive perception. On the other hand, Lubbock's experiments ("On the senses, instincts and intelligence of animals" [London, 1889], p. 233 and foll.) have shown that an arbitrarily chosen sign or password is equally out of place, as is evident from the fact that an ant which has lost its feelers is nevertheless recognized by her nest mates.

of the same colony have the same delicate "nest odor," and by licking strangers they are able to transfer it to other insects. A beetle of the genus *Atemeles* having been licked in a friendly manner by but *one* ant of a *Formica* colony, will be acknowledged as a friend by the other ants of the same colony, whilst otherwise they would attack it.[1] The "nest odor" can be communicated to members of other colonies not only by licking but also by feeding. The smell of the *salivary gland secretions*[2] thus seems to serve ants as well as bees as a means of recognizing the "citizens of the same state."

It is, no doubt, downright nonsense for Buechner[3] to put ant states on the same level with human republics, much more so to consider them more perfect than the latter. And when modern sociologists[4] try to establish their reforms of human society on such foundations, we are justified in styling their endeavors utopian schemes. The promoters of such ideas for-

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[1]) More on the significance of the salivary gland secretions as a means of recognition among ants will be found in the essay mentioned above "Die psych. Faehigkeiten der Ameisen," p. 16 and 97 ff. On the latter pages we have also shown that it is not *merely* the smell of the salivary gland secretions adhering to a beetle, that induces the ants to receive it after it has been licked by a *single* ant of that colony, but that, besides, other psychic elements are in play and must be considered in explaining the fact. See also "Instinct and Intelligence in the Animal Kingdom," p. 158.

[2]) See the interesting little essay by N. Ludwig, "Futtersaft oder thierische Veranlagung als der Beherrscher und Ordner geheimnissvoller Vorgaenge im Bienenvolke," published by the "Leipziger Bienenzeitung," 1896. Likewise N. Ludwig, "Ueber Geruchempfindung und Riechorgan der Honigbiene" ("Natur und Offenbarung," 1899, 9th issue, p. 554 ff.).

[3]) "Geistesleben der Tiere," p. 52.

[4]) See e. g. Cognetto de Martiis, "Le forme primitive nella evoluzione economica." Torino, 1881.

get, that with man class differences rest on far different bases than differences of castes among ants. With man they are the outcome of changeable, outward conditions of life, or perhaps the result of the intelligent free choice of the individuals concerned; with ants, however, they spring directly from the hereditary organic laws of polymorphism. Besides, those socialistic theorists forget that among ants there exists perfect equality and fraternity between all the members of a colony, for the very reason that these animals are guided by their social instincts *only*, not by independent reasoning, and that they therefore are never liable, as men unhappily often are, egotistically to prefer their individual welfare to the common weal. If those socialist enthusiasts could transform men into ants, then they might be justified in proposing ant republics as the ideal political condition.

H. E. Ziegler[1] is right, therefore, in saying: "With ants the social differentiation is conditioned by organization and instincts, and is thus accurately fixed and regulated, whilst with man the social differentiation is due to education, exercise and custom; only the foundation of man's social life is determined by certain social instincts, its further development, however, is regulated by the intellect, by education and custom . . . . To argue about man's social institutions from the relations existing among insects would be *committing a gross error*, all the more so, if one should consider the communistic insect 'states'

[1] "Die Naturwissenschaft und die socialdemokratische Theorie," p. 186. See also R. Leuckart, "Ueber den Polymorphismus der Individuen oder die Erscheinungen der Arbeitsteilung in der Natur," Giessen, 1851.

as models of human communism." Smalian[1] agrees with Ziegler on this point, and I hardly believe that any intelligent naturalist will dispute their position.

But now let us examine the other conclusions these statements imply.' The social life of ants in spite of its differing essentially from the *human* state, is nevertheless the *highest degree of community life in the whole animal kingdom*; even the social relations among the highest apes are far from reaching the perfection of ant states. The *foundation* indeed of social life and division of labor in ant states is *organic,* and is to a certain degree predetermined by nature with aprioristic necessity through bodily polymorphism. Nevertheless, also with them the *actuation* of the social instincts is guided and determined in its details by the sensile cognition and experience of the individuals. Whoever falsely styled this *individual sensuous experience* of higher animals, such as dogs, apes, etc., *intelligence,*[2] should not be so inconsistent as to deny to ants a high degree of the same *"individual intelligence."* Whoever without previous critical analysis of his psychological notions maintains downright, that associations resulting from the sensile experiences of the individual are intelligent, must credit ants not only *with the highest development of the social instincts, but also with the highest development of intelligence found in the animal kingdom.* This we wish to prove more in detail.

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[1]) "Altes und Neues aus dem Leben der Ameisen," in "Zeitschrift fuer Naturwissenschaft," LXVII (Halle, 1894), 39.

[2]) Which is done by Ziegler and nearly all modern zoologists, as we have shown in "Instinct and Intelligence," chapt. 2.

In what does the pretended psychological superiority of the associations of higher animals over ant states consist? Let us try to clear up this question.

b. The Communities of the Higher Animals Compared with those of Ants.

Both Ziegler and Darwin[1] point to the fact, that the higher mammals, especially apes, "sometimes form societies for the purpose of receiving notice of danger, for providing mutual protection and defense, for obtaining nourishment, sometimes even for united attacks on their prey"[2]. Societies of ants have the very same end in view. Although their main purpose is to rear their young in common, yet these other secondary purposes are not only not excluded, but their pursuit and attainment by ants reach a degree of perfection surpassed by the above mentioned higher animals. However, neither Darwin, nor Espinas, nor Ziegler, nor, in fact, any modern student of animal psychology has ever succeeded in proving that apes are conscious of their purpose, and therefore act with intelligence, and that ants are without consciousness of purpose, and therefore acting merely from instinct.

Let us consider more closely the different points of comparison. The higher animals living in hordes call their comrades by certain calls, giving warning of danger. Some of them, e. g., the chamois, post regular "sentinels" for this purpose. However, ants do the same and in a manner much more indicative

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1) "Descent of Man," I. Chap. 4.
2) Ziegler l. c., p. 180.

of intelligence. The whole difference lies in the fact that instead of calls, the ants use another means of sensile communication, namely, their feelers. If a troop of "sanguine slavemakers," as McCook calls them, (*Formica sanguinea*), approaches a nest of the negro ant (*Formica fusca*), then the first black ant which has noticed the foe hurries back into the nest, communicates her own fright to the other workers by rapidly tapping them with her feelers and thus gives a general alarm. The larvae and pupae are hurried down from the higher parts of the nest into the deeper galleries and chambers, and if the foe advances as far as these apartments, the black ants run head over heels through the secret openings at the opposite side, and with their precious burden climb up stalks and bushes to save it from the foe. Sometimes they resort to this final means of escape at the first news of danger and take to their heels before the vanguard of the foe has reached the interior of the nest. In a similar way, but adopting different tactics, the yellow and the brownish-black meadow ants (*Lasius flavius* and *niger*) struggle for safety, when their nests are attacked by some *Formica* species. As soon as the approach of the foe is discovered, the fact is announced with lightning-like rapidity throughout the colony by rapid strokes of the feelers. The larvae and pupae, the winged males and the queens are carried to the lowest recesses of the nest, and the avenues to it are hastily blocked up with earth to prevent the enemy's advance. Whilst the small *Lasius* is constantly closing up the approaches to the interior of the nest with bits of earth, such of the foe

as have ventured too far, are seized and killed by crowds of the assailed.

If with higher animals it is a mark of intelligence to "utilize the senses of all for the protection of the commonwealth," the same must be said of ants, and in a more perfect degree. The posting of sentinels for the protection of the community may be observed with these social insects just as well, and even better than with the social apes. In a nest of *Formica sanguinea* comprising four species of slaves (or auxiliaries), namely, *F. fusca, rufibarbis, rufa* and *pratensis,* which is under my observation for many years, I can verify this fact every day. We subjoin a diagram of this observation nest, as it will often be referred to in the sequel.

The main nest and its annex are made of glass plates in wooden frames. The space between the two plates in each nest is partly filled with earth, their vertical distance being from 10 to 12 millimeters, so that the ants have freedom of motion to perform their work without being able to screen themselves from observation. The upper glass plate is generally covered with a black cloth; for if light were permitted to enter, the ants would coat the lower surface of the glass with earth in order to darken the interior of the nest. By means of glass tubes the main nest and its annex are put in communication with each other and with the other parts of the nest, which are likewise of glass. (See diagram.)

In the main nest, which corresponds to the interior of an ordinary ant nest, the majority of the ants are to be found with their queens, their larvae, pupae and

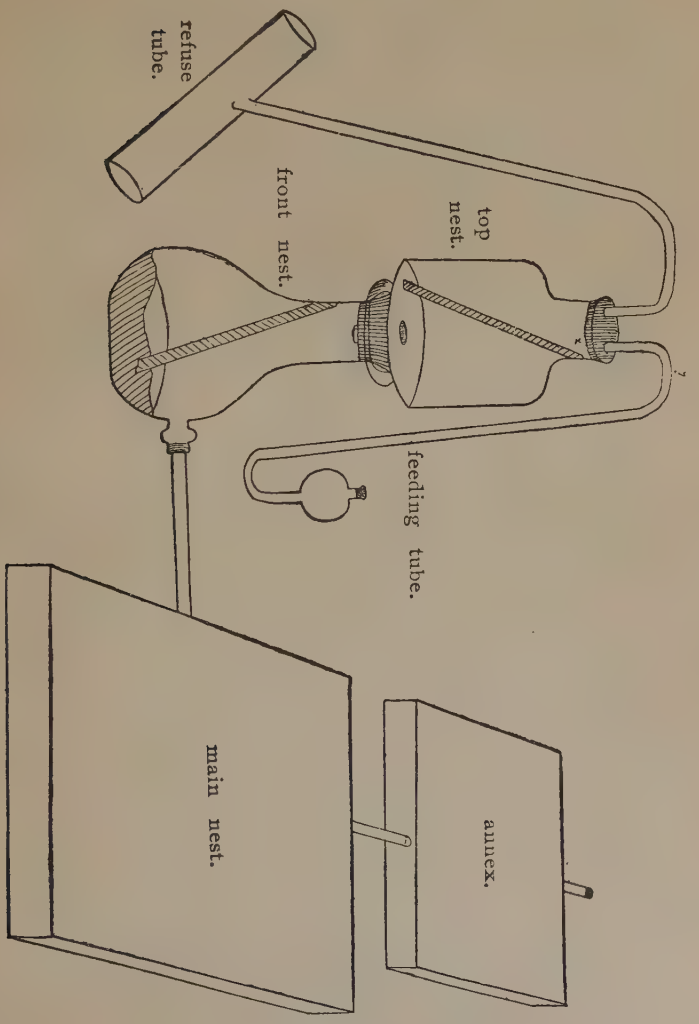
refuse tube.
top nest.
front nest.
feeding tube.
main nest.
annex.

Fig. 1.

guests. In the front nest we see generally a number of ants basking in the sun or engaging in different labors. In the top nest a small number of *sanguinea, rufa* and *pratensis* are usually found either on guard, or waiting for the flies or other food which I occasionally throw in. In the glass bulb of the feeding tube, even if it happens to contain no sugar or honey, there are always one or two ants, mostly *fusca* or *rufibarbis,* which have a special liking for this department. Even on the dumping grounds, whither the ants carry their dead, there are, as a rule, a few ants to be found, remaining immovable and watching for any suspicious circumstance in the nest or in its vicinity. On March 26, 1896, from morning till evening one *F. fusca* and one *F. pratensis* were posted in the refuse nest; on March 27, at 7 a. m. two *F. pratensis;* at 10 a. m. two *F. sanguinea* took their place. On March 28, in the forenoon, one *sanguinea* was on guard, which having been taken out by me and confined was soon after replaced by another *sanguinea* for the rest of the day. On March 29 the whole day one *sanguinea*; on March, 30 at 7:30 a. m., two *fusca*; when at 8 a. m. I had taken out and confined one of the two, I found that within the space of half an hour another *fusca* had taken its place, whereupon both remained there during the whole of the forenoon, etc. Only during winter, after I had completely emptied the refuse nest and left it in the same condition for a long time, no ants were seen there for several weeks, because this part of their nest was no longer of any vital interest to them, and because the cool temperature kept them in the main

nest and in its immediate vicinity. It can hardly be maintained that this posting of sentinels in the different parts of the nest was *merely due to polymorphism;* for the cognitive and appetitive powers of the single individual ants of those five species in various ways take a prominent part in it. As we shall show hereafter, the same obtains in other forms of the division of labor in ant states.

"Social animals perform many little services for each other; horses nibble, and cows lick each other wherever they feel an itching; monkeys hunt for each other's external parasites," etc. Thus Ziegler reproduces the statements of Ch. Darwin. But ants of the same colony are quite as serviceable to each other. Whoever has kept ants in suitably arranged nests of observation, where they feel comfortable and at home, can observe such "acts of charity" a hundred times a day. Every time I gently lift the black cloth, which protects the upper glass plate of the main nest from the rays of the sun, I witness one or more of these lovely scenes. Just now a worker of *F. sanguinea* is lying immovable, stretched on her side, whilst some of the companions are washing her; a *sanguinea*, a *fusca* and a *rufibarbis* perform this work, and lick her carefully, whilst she continues immovable; then they turn her around and lick her just as carefully on the other side. After half a minute the light which floods the nest interrupts the performance, and they flee to some darker spot, the patient soon following their example. All the workers of each of the five ant species living in my mixed colony without distinction render these services of cleanliness to one another.

Sometimes one of the dominant, sometimes one of the enslaved species is the recipient, no distinction being made between masters and slaves in performing these offices. Just as with cows in licking each other, so with ants, the performance of this service generally causes no less satisfaction to the active than to the passive partner, and, when apes look for each other's parasites, we must, in order to arrive at a correct psychological appreciation of such "kind offices," not overlook the fact that apes devour with great relish the parasites discovered in the fur of their comrade.

As regards these mutual cleaning services, ants and the higher social animals are pretty much on a par. The only difference is, that with ants they occur much oftener than with the latter. In both they proceed, in the first place, from the *desire for cleanliness*, which is no doubt of an instinctive nature.[1] In the second place, they are due to the instinctive, *mutual attachment* between the members of animal associations. The fact that ants clean a dust-covered companion by carefully "brushing" her down with their mandibles and licking her with their tongues, when viewed from the point of comparative psychology, finds its explanation in the same psychic motives as when "apes, after having rushed through a thorny brake, will examine each other's fur and extract every thorn or burr." To lick off the dust is, *by itself*, not more agreeable for ants; than it is for monkeys to extract the thorns.

With ants the mutual attachment of nest mates

[1] See Bellion, "De l'instinct de la propreté chez les animaux." 2d ed., Bazas, 1895.

goes so far as to make them *carefully tend their wounded and sick companions,* which is not the case with gregarious mammals. The above-mentioned observation nest of *F. sanguinea,* on which I bestowed special care and attention, allowed me to observe several times, so as to leave no doubt of the fact, that, without distinction of masters or slaves, sick companions, or such as were paralyzed by the formic acid of hostile ants, were carefully nursed and licked for whole days, until they recovered. Forel, too, considers it a general rule, that ants nurse their sick or maimed companions.[1]

Ants as "sick nurses" seemed so strange to me, that I was unwilling to admit the fact, until I observed it myself. The first time was on March 16, 1895. I had replaced in the main part of the aforementioned nest a *sanguinea* which had been paralyzed in one of the narrow glass tubes by an ejection of formic acid, and was scarcely able to move in spite of her convulsive efforts. At first her companions, on approaching, appeared to take no notice of her distress. Yet, after a short time, they began to examine her with their feelers, and then carried her to another part of the nest where the greater number were assembled. In this place the sick ant was lying for the whole day, surrounded by a number of masters and slaves (*fusca*) which, mostly in groups, busied themselves about her. They licked her carefully, turned her over and licked her again, examined her with their feelers and licked her once more. This method of medical treatment was attended with complete success. The patient had fully

[1]) See Lubbock, "Ants, Bees and Wasps," Chap. V, p. 88 ff.

recovered by the next day, whilst without nursing she would probably have perished, as is generally the case with ants paralyzed by poison.

If, therefore, on account of this "nursing," Lubbock and Romanes ascribe to ants a certain degree of "care and tenderness" lavished on their sick and wounded companions, they are right in so far as those actions are due to instinctive impulses, and not to the conscious affections of rational beings. For comparing the associations of ants with those of higher animals it may, at any rate, be of particular interest to notice, that such acts occur also among ants, notwithstanding their highly choleric temperament.

"Yet, social animals also render more important services to one another; thus wolves and some other beasts of prey hunt in packs and aid one another in attacking their victims. The Hamadryas baboons turn over stones to find insects, etc., and when they come to a large one, as many as can stand round, turn it over together and share the booty. Social animals mutually defend each other." This quotation from Darwin's "Descent of Man" cannot justify Ziegler any more than his former arguments in concluding, that the community life of wild cattle, baboons and other mammals is more closely related to the social organisms of man, than that of ants. On the contrary, the manifestations of social life recorded above occur with ants even in *far greater perfection*.

Ants, too, hunt in company, especially the so-called sanguine slavemakers (*F. sanguinea* and *rubicunda*), the red *Amazon* ants (*Polyergus rufescens*, *lucidus* and *breviceps*), and all the species belonging to the

Dorylide genera *Eciton* and *Anomma.* These are the dreaded legionary ants and driver ants of tropical America and Africa. The military expeditions of *F. sanguinea* are generally undertaken in small divisions of from twenty to fifty workers, with the purpose not only of robbing the neuter pupae of the slave species (*F. fusca* and *rufibarbis*), but often also of pillaging the nests of smaller ants belonging to the genus *Lasius*, the larvae, pupae and winged individuals of which are carried off to be devoured. During the time of the nuptial flight of *Lasius niger,* many *sanguinea* colonies are hunting in the vicinity of their nest for the heavy *Lasius* females which drop to the ground. Then either singly or with united forces these robbers pull their victims into their strongholds, where they are mercilessly slaughtered. On the afternoon of August 24, 1888, I witnessed such a typical hunting expedition of several *sanginea* colonies near Exaten (Holland), on the outskirts of a fir plantation. The road passing the nests was covered far and wide with *sanguineas* rushing upon every *Lasius* female that dropped from the air, as upon a welcome booty. Within the space of an hour I counted more than one hundred females of *Lasius niger* that fell victims to the hunters.

The individual initiative of ants is manifested on such occasions in the same degree as with the higher mammals; whilst concerted action and suitable co-operation reach even greater perfection than with the latter. At any time a troop of our common red-backed hill ants (*F. rufa*) may be seen on some forest path, with combined forces dragging to their home a

large, heavy dung-beetle (*Geotrupes typhoeus*); or a number of them are hauling to the nest a large beam—to our eyes it is but a broken twig—which is more than fifty times the weight of any single ant! Some pull in front, others push from behind, and even if the latter for a few seconds pull in the wrong direction, they soon notice it, and off it goes in the right direction to the nest. On April 25, 1897, I observed in the neighborhood of a *pratensis* nest near Exaten, two workers dragging together a beetle of the genus *Calathus* towards their hill; they went at a double-quick, without hindrance on either side, both ants running backwards with equal speed.

The mode of acting in concert is different with different species of ants. Among our *Formica* species it reaches its highest degree of development with the hill ants (*F. rufa* and *pratensis*), the initiative of the single ants bearing rather a secondary part. The sanguine slavemaker (*F. sanguinea*), however, which is able to proceed *unitis viribus* wherever it seems suitable, combines with this power a remarkable degree *of individual initiative,* similar to that noticed in dogs, apes, and other higher animals.

It is of special interest to watch the co-operation and division of labor of different species in *mixed colonies* of ants. In my above mentioned observation-nest, which contains besides *F. sanguinea* four other *Formica* species as auxiliaries, these five species have divided the work necessary for the welfare of the community, so as to give each species exactly the share corresponding most to its instinctive preferences. This division of labor, however, is neither mechanically

defined, nor confined within the cast-iron rules established by the specific character of each ant, but the workers of one species will at least to some degree take part in the work of any other species. Thus e. g. the rearing of the young in the main nest (see p. 23) is chiefly attended to by the *sanguineas* themselves, but all the four auxiliary species join in the same work. In the glass bulb of the feeding tube containing the sugar, the greater number of visitors consists of *fusca* or *rufibarbis* filling their crops by licking up sugar or honey, with which they hurry to feed their companions in the other parts of the nest. *Sanguinea, rufa* and *pratensis* often prefer to carry the grains of sugar "in the lump" from the feeding tubes to the top nest, manifesting again various individual differences in their mode of action, quite independent of their specific character. Sometimes the lump of sugar is carried only as far as *y* (see diagram on p. 23) to the top of the tube, whence it is transported by other ants ; generally, however, it is immediately brought (beyond *x*) to the front nest, where it is carried to the bottom in their mandibles, or else, but rather seldom, it is simply dropped from a considerable height. This I observed quite often with *sanguinea,* more rarely with *pratensis.* When I introduce a large fly or some other live victim into the front nest, it is mostly *sanguinea* and *rufibarbis* that dart upon it furiously, whilst *rufa* and *pratensis* manifest on such occasions remarkable skill and perseverance in holding down the struggling and fluttering victim. The *sanguinea* with their powerful mandibles attend chiefly to the dismembering of their prey, whilst the conveyance of the larger pieces

into the inner parts of the nest is generally done by *rufa* or *sanguinea*.

It was of special interest to watch the behavior of my ants, when a new individual of the beetle *Lomechusa strumosa* which lives with *F. sanguinea* as a genuine guest, was introduced into the top nest. At first, as long as there were no *rufa* and *pratensis* in the nest as auxiliaries, he was, if not descending into the main nest himself, taken at last by a *sanguinea* and carried down, in spite of his obstinate, passive resistance. Later on it was generally *rufa* and *pratensis* that transported the guest who attracted their attention in a remarkable degree. Once a *rufa* happened to be alone in the top nest and for a long time was trying in vain to get hold of one of the two *Lomechusas* happening to be there, when all at once she ran down to the front nest. Scarcely more than three seconds had elapsed before she returned with four other *rufas* which she had called to her assistance. Now the five *rufas* immediately set to work with united efforts to raise the *Lomechusas*, each of which was then carried down to the main nest by one of the ants.[1]

If similar scenes had been witnessed in a society formed of different species of higher animals, we could not help admiring the harmonious co-operation and the suitable, but by no means mechanical, division of labor. However, it is not the higher animals, but *ants* that act in this way, and in order to save the pretended intelligence of the former, ants are classed as *in-*

[1]) A more accurate description of the last-mentioned observation will be found in our essay, "Die psychischen Faehigkeiten der Ameisen" ("Zoologica," 26th issue, Stuttgart, 1899), p. 63 ff. in the chapter on the power of communication in ants.

stinctive automatons, or even as unperceptive *"reflex machines" !*

Yet, neither in ants nor in any other animals, are co-operation and division of labor such as to become *mutual, individual assistance,* as is the case with man. The same object attracts the attention of several individuals and leads them to busy themselves about it, each in its own way. Working in company is due partly to the similarity of instinctive dispositions in the single ants, partly to the instinct of imitation. H. v. Ihering refers to this in the case of the Brazilian leaf-cutting ants (*Atta*), and has pointed out the psychological importance of this difference as it exists between societies of animals and man.[1]

Everybody knows that not only the higher mammals but also the social insects *unite in defending* their community and especially their young. To be thoroughly convinced of this fact you need but step on a wasps' nest or sit down on an ant hill. Indeed, the perfect unity and heroic "self-sacrifice" which social insects and in particular most ants display in defending their nests and their offspring are *simply unsurpassed by any other animal.* This "unselfishness," this "spirit of sacrifice" and "motherly love" in animals will be referred to in particular, when we come to speak of the breeding and nursing instincts.

Higher gregarious animals, e. g., bisons or baboons, do not in defending the community against a common foe defend also the individuals as such. When a hunter lying in ambush has killed one of the herd, the

[1]) "Die Ameisen von Rio Grande do Sul," in "Berliner Entomologische Zeitschrift," 1894, 3d issue, p. 346.

other bisons generally take an inquisitive sniff at the corpse, but they make no assault on the foe for the sake of a wounded or dead companion. Wolves are far more unceremonious. Instead of devising plans for revenge, they devour their dead or wounded "brother." Ants, when engaged in common defense, aim at defending the individual of the colony just as little as do the higher animals. An assailed ant is never defended by her companions for her own sake. They rush upon the foe, only because they see in him a common danger, and because their warlike spirit has been aroused. This was noticed by Forel and Lubbock, and I can only confirm it. Therefore, neither higher animals, nor ants, when either at work or in battle, manifest anything like individual assistance in the *human* sense of the word.[1]

"All animals living in a body, which defend themselves or attack their enemies in concert, must indeed be in some degree *faithful* to one another ; and those that follow a leader must be in some degree *obedient*. When the baboons in Abyssinia plunder a garden, they silently follow their leader ; and if an imprudent young animal makes a noise, he receives a slap from the others to teach him silence and obedience."

Examples perfectly similar to the one just men-

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[1]) The pretended instances of individual assistance in the legionary ant *Eciton hamatum* recorded by Belt (The Naturalist in Nicaragua, 2d ed., 1888, p. 26), are easily explained by the fact that these migrating ants tried to take along their straggling companions, as is often the case in migrations of European *Formica* species. Therefore, there is no reason why we should credit the *Ecitons* with a higher "sympathy for their companions" than other ants, as Romanes does ("Animal Intelligence," 6th ed., p. 480). This case is no proof of sympathy, but merely a manifestation of the instinct of sociableness.

tioned, and which Ziegler has borrowed from Darwin's "Descent of Man," may, when purged of arbitrary anthropomorphic interpretations, be recorded also of ants. He who takes the terms "fidelity" and "obedience" as they are applied to human beings, namely as reasonable, voluntary subjection to the demands of duty and authority, can ascribe "fidelity" and "obedience" to baboons as little as to ants. From the point of view of critical psychology it is ridiculous to interpret the "slap" given to the young baboon by its senior to be, as among men, an admonition to fidelity and obedience. The imprudent cry uttered by the young baboon, if the story is to be credited at all, excited the instinctive anger of the old apes as they were silently advancing. The instinctive association of certain sensile perceptions with certain sensile impulses affords a much simpler and more natural explanation of this fact. If, therefore, Darwin and Ziegler on this account ascribe to baboons fidelity and obedience in the human sense,[1] they are but arbitrarily humanizing the brute, as indeed Darwin has done time and again in the book quoted above.

A slight analogy of what we call fidelity and obedience may indeed be observed in many animals, not only in the higher species, but also in state forming insects. Wherever a certain individual is the center of operation for the instincts of the rest of the community, the latter will show it *fidelity and obedience.* The swarming bees cluster around their queen "faithful and obedient." This allegiance is, of

[1]) See my former essay, "Instinct and Intelligence in the Animal Kingdom." (Herder, St. Louis, Mo.)

course, not so prominent with ants, whose queen is much less of a center for the instinctive activities of the workers. With ants it is just the workers that by their restless activity and the remarkable display of individual initiative, are most powerfully stimulating the instincts of their companions to imitation, and thereby to actual co-operation in a given work. The only difference between the baboons described by Darwin and our ants is, that with the former the instinctive communication between the single individuals of a troop is effected mostly through calls, with the latter, however, through taps of the feelers. But both sometimes resort to more drastic gestures to supplement their means of "communication." If an excited *F. sanguinea* or *fusca* can not succeed by taps of her feelers in inducing a companion to join her work, she sometimes seizes her by the mandibles or by a leg and simply drags her to the object which had first attracted her own attention. In the same way an ant often protects her comrades from a threatening danger first noticed by her. In my observation nests I repeatedly noticed some *F. sanguinea* or *fusca*, by taps of her feelers or some other more drastic measures warning their companions to be "on their guard." When, e. g., I took away the glass tube connecting the feeding bulb with the top nest (see diagram p. 23), and caught a few of the "sentinels" that instantly sallied forth from the opening of the top nest ready to fight, I often remarked some ants, that were posted near the opening of the top nest, approaching the others, tapping them with their feelers as a danger signal, and even getting hold of one, that

was about to run out, and *pulling her back* from the dangerous spot. To interpret such psychic manifestations in higher animals as "intelligent actions" is evidently inconsistent with denying to ants an equal or even higher degree of "individual intelligence." Critical psychology will regard such occurrences in ants as well as in higher animals merely as *associations of sensile representations and impulses,* which must be classed as *instinctive sensation,* and not as *intelligent thought.*[1] The social instincts of animals, which in their actual use are variously influenced and ruled by individual sense experience, perfectly explain all the appearances of "fidelity," "obedience," "caution," etc., which occur with state-forming insects not in a lower, but rather in a higher degree than with apes and other mammals. To credit higher animals with quasi-human intelligence is, therefore, to humanize animals in a manner equally arbitrary and inconsistent.

To sum up the *results* of our comparative study on the social life of ants and of higher animals. The associations of apes and of higher Vertebrates are based on *social instincts,* which lead them to co-operate for mutual protection and defense, and partly, too, for the procuring of food. This co-operation is more or less powerfully influenced and varied in its manifestations according to the sensile experiences and affections of different individuals. Exactly the same mode of co-operation, but of a still more *perfect, suitable,* and *variable* nature, we observe also in *ant states.* With these animals, too, it is founded on *social*

[1]) See "Instinct and Intelligence in the Animal Kingdom" (Herder, St. Louis, Mo.), especially Chap. III.

instincts, which, corresponding to their organic polymorphism, are different in different classes (castes) of the state. As regards the application of the sensile experiences and affections of individuals, there exists within the range of these classes a very great independence and variableness of individual action, which with several ant species, e. g., the sanguine slavemaker (*F. sanguinea*), is scarcely inferior to that observed amongst higher Vertebrates. Besides, the *perfection of social co-operation* of higher mammals is far from equaling that of ants; for with the latter it extends not only to protection, defense and hunting, but also to construction of their dwellings, to the rearing of the young, and to the support of all the "members of the state" by comparatively few individuals, going by turns in quest of food and supplying the community with provisions. Nothing of the kind is known of apes or other higher animals. The *providing of food* in particular varies greatly with the different kinds of ants: it embraces "cattle herding" (the keeping of aphides), hunting (robbing of insects, in particular, robbing of the pupae of other ants), agriculture (grain gathering ants), horticulture (ants raising fungi), etc. Nor are the military expeditions of several ant species undertaken merely from want of food, but also for the sake of making slaves, the ravished pupae of workers of other ant species being reared as members of their own state. Through this suitable incorporation of outsiders into their own colony the community life of ants in the "*united colonies*" reaches a quasi-intelligent universality, which is vainly sought for among higher animals. The same universality is manifested also by

the fact, that many ant species treat like members of their own family even different orders of insects, namely the beetles of the genera *Atemeles, Lomechusa, Xenodusa,* etc., which are known as *"genuine ant guests,"* and that they even tend and rear their young as if they were their own.

It must, therefore, be conceded that the community life among ants is more developed and more perfect than that among apes and other higher animals ; *hence, from the point of view of comparative psychology, the communities of ants represent the most perfect of animal societies.*

CHAPTER II.

WARS AND SLAVERY IN THE ANIMAL KINGDOM.

1. *Wars Among Higher Animals.*

MODERN evolutionists represent the social life among higher Vertebrates with the aim of making it the main support of the bridge spanning the chasm between man and the brute. Thus, Ziegler concludes his description by a psychological parallel, in which, just as Darwin did, he tries to establish the greatest possible similarity between the social life of animals and of man. Let us examine this evolutionistic attempt in the light of scientific psychology.

Says Ziegler: "There exists, *therefore*, among animals a social community life similar to what we meet among the hordes and tribes of uncivilized nations. Even wars, which have taken place among the hordes and tribes of the human race since prehistoric times, have their counterparts in the animal world, as is proved by the following example recorded by Darwin.

"'Brehm states on authority of the well-known traveler Schimper, that in Abyssinia, when the baboons belonging to one species descend in troops from the mountains to plunder the fields, they sometimes encounter troops of another species and then a fight ensues: the *geladas* roll down great stones, which the *hamadryas* try to avoid and then both species, making a great uproar, rush furiously against each other.'"

How far the "*therefore*," which should connect

the social life of animals and of man, is supported by facts, has been shown in the preceding chapter. Even in higher mammals individuals of social communities co-operate merely *as far as their social instincts guided by individual sensile experience will allow.* In man, however, community life is due to social instincts *as to its foundation only, but in its perfect development to the intelligent, free self-determination of individuals.* Ziegler and Darwin are far from having furnished the proof, that the latter element occurs also in higher animals. Or do they perhaps think that the wars which hordes of apes wage against each other contain this proof? Let us see.

In the above description it is stated that the baboons roll down stones at their enemies *intentionally,* and thus, as it were, use the stones as weapons, as e. g., in 1809 the Tyrolese occasionally did in their struggle for liberty against the French and Bavarians. But regarding apes, the statement is a myth. Pechuel-Loesche corrected the passage in the third edition of Brehm's "Tierleben." "We are told," he writes, "that apes defend themselves with broken branches, and it is pretty generally assumed that they hurl down on their opponents stones, fruits, pieces of wood and other objects. This belief is probably due altogether to *inaccurate observation.*[1] Its originators and abettors have perhaps seen only, what they from various

[1]) We sincerely regret that Mr. Pechuel-Loesche was not allowed to subject the 3d ed. of Brehm's "Tierleben," which he revised, to a thorough psychological revision. Although several of the most offensive passages were corrected or omitted, yet Brehm's peculiar style has not changed; he cannot possibly refrain from intentionally humanizing the brute. See a criticism of this work in "Natur und Offenbarung," XXXVII, 570.

accounts supposed to be the fact, not what took place in reality. Apes living in trees, in wanton playfulness, break off withered branches by jumping on them, by snapping and shaking them ; but they do not throw them at a person who stands below. Neither do they throw fruits or other objects which they hold in their hands; they rather drop them quite naturally on being frightened or put to flight. Moreover, baboons, among which I was able to observe especially the *tschakmas,* often watching hundreds of them very carefully, never think of throwing down stones from their rocky elevations at their pursuers. It is true, from the place where they happen to be, stones sometimes roll or fall down, but merely by chance and also at times, when no enemy is in sight. . . . Together with my wife, who derived great pleasure from watching the behavior of the baboons,—they were often the only living beings, and very noisy at that, in the rocky deserts of South-western Africa,—I have minutely studied their doings precisely on this head to convince myself whether they actually throw. *They assuredly do not.*"

What light is thrown by these critical observations of Pechuel-Loesche on the "individual intelligence" of apes so highly prized by modern evolution? Light enough, indeed, but extremely compromising for that theory. In spite of their highly developed brain, which in anatomical structure bears the closest resemblance to the human brain, apes are nevertheless unable to draw even the *simplest conclusions,* which might lead them to the use of branches and stones as weapons. The spider weaving its ingenious web to ensnare its prey, or casting out silky threads to entangle its vic-

tim; or the "ant-lion" (*Myrmeleon formicarius*), an insect belonging to the Neuroptera, the larva of which from the center of its funnel-shaped sand-pit with its long and flexible mandibles hurls particles of sand at an ant, to bring her to the bottom of the pit ; or the archer fish (*Toxotes iaculator*), directing jets of water upon small insects resting on aquatic plants, thereby bringing them down into the water as his prey : these animals, so low in the zoological scale, are far nearer to man, as regards the suitable use of weapons, than the highest apes, although on evolutionistic principles the latter only could possibly form the transition between man and the brute. That apes through their imitative instincts and by human training are able to "learn" the use of a few simple tools, only proves the *intelligence of man and the power of sensitive perception in apes.*[1] Had apes *themselves* but a trace of intelligence, they would have invented long ago even in their free state of nature the use of a few simple means of defense, such as branches and stones. But why did they not? The only possible, *scientific* answer is : *because they evidently have no intelligence.* Not the *brain* alone makes man an intelligent being, but *his spiritual soul,* and this spiritual soul is wanting in the highest apes as well as in insects. True, modern evolution is fond of ignoring all facts, which will not fit into its tissue of hypotheses. But we need not say that such a proceeding is highly unscientific.

Darwin's and Ziegler's attempt at putting the wars of apes on a level with those of uncivilized tribes, has

1) See "Instinct and Intelligence," etc. (Herder, St. Louis, Mo.), p. 60 and 160.

proved unsuccessful. Even the most savage nations employ tools and weapons of various kinds in order to catch their prey or to wage war against their foes. The parallel drawn by Darwin and Ziegler between the wars of apes and of savages proves to an unprejudiced observer the *very reverse* of what Darwin and Ziegler intended to prove : it proves *the essential difference between the merely sensitive, psychic faculties of the highest vertebrates, and the spiritual, mental faculties of man.*

2. *The Military Expeditions of the Amazon Ant and of the Sanguine Slavemaker.*

The wars of ants bear far greater resemblance to human wars than those of the apes. Indeed, ants no more than other animals use any other weapons than those furnished by nature, namely their swordlike mandibles, their poison stings and poison syringes, but they use them in a manner which of all animal combats most resembles human strategy. Whoever watched a military expedition of the red Amazon ants (*Polyergus rufescens*) or of the sanguine slavemakers[1] will no longer entertain any doubts on the subject. The Amazon ants, the European *Polyergus rufescens* as well as the North American *P. lucidus*,[2] advance

[1]) Since the issue of the book, "Die zusammengesetzten Nester und gemischten Kolonien der Ameisen" (1891), I have had occasion in Lainz near Vienna to observe a number of other *Polyergus* expeditions, and besides, several *sanguinea* expeditions near Vienna and in Limburg (Holland), etc.

[2]) Called by McCook the "shining slavemaker," whose habits he observed near the Allegheny mountains. There are still three other subspecies (races) of *P. rufescens* found in N. America, *P. breviceps Em., bicolor Wasm.* and *mexicanus For.*

on the war-path in large serried columns, the sanguine slavemakers, however, the European as well as the North American,[1] in smaller, less serried detachments ; both, but especially the Amazons, try to storm the hostile nest by a fierce attack, and to stun the numerically superior foe and to put him to flight by the suddenness of the onslaught. Great success generally attends these tactics. Forel, in his "*Fourmis de la Suisse*" (1874), p. 306, has several similar instances, some of which we wish to bring to the notice of the reader. When Forel brought a bag containing a whole colony of meadow ants (*F. pratensis*), which in size and strength surpass the Amazons, into the neighborhood of an Amazon nest, several of the Amazons at first dashed fiercely into the midst of their numberless enemies; twenty of them were as a rule sufficient to rout fifty times that number of *pratensis*. Another time an army of Amazons just returning from the pillage of a slave nest were depositing their spoils of ant pupae in their nest, previous to setting out on a new expedition, when Forel at a distance of one meter from their nest and in the path of their expedition emptied a large bag of *F. pratensis*. In three minutes the whole army of the Amazons had encircled the hostile camp appearing quite unexpectedly. They stormed it in an instant, drove out the *pratensis* and ransacked the nest for its cocoons.—I would like to hear of apes ever displaying similar military skill.

It is characteristic of the military tactics of those

1) *Formica rubicunda* and *integra Em.* are the principal N. American races of the European *Formica sanguinea*.

ant species which undertake slave hunting expeditions, to kill the hostile ants only when resistance is offered. Fleeing *F. fusca* or *rufibarbis* are pursued merely to obtain the larvae and pupae which they are carrying off; booty, not slaughter is the object of the victors. If apes or other higher animals were to act similarly in their wars, then our modern advocates of evolution would not fail to make the following reflections: "Here we find the first traces of *genuine humanity,* which shrinks from unnecessary bloodshed; what these animals *consciously aim at* is, not *to fight,* but to *gather the fruits of victory,*" etc. In ants such reflections are readily granted to be ridiculous humanizations of the brute; but never would it be conceded in the case of apes, not because the psychic manifestations are really different, but rather to safeguard the evolutionistic theories.

The military skill of the Amazons (*Polyergus*) is no doubt unexcelled amongst ants, but also amongst other animals. It is even far superior to the military tactics of the sanguine slavemaking ants, although the latter manifest in their whole character a more perfect development of what is called "individual intelligence," i. e., the suitable application of their sensitive experiences. But the Amazons in private life are the dullest and most awkward *"instinct beings"* you can imagine. Although they *are able* to take liquid food by licking just as other ants, they have nevertheless almost totally lost the instinct of feeding themselves, and would starve, unless they be fed from the mouth of their slaves. This fact makes it quite evident, that even in the grandest military exploits of the Amazons there

enters not the slightest trace of genuine intelligence, but only instinctive sensitive faculties; for, an animal, that even in a state of utmost destitution is unable to combine his feeling of hunger with the perception of nourishment and the impulse to eat, can surely not be credited with even the lowest degree of *deliberation. "A being that is physically able to eat, but has lost the habit of it, is the greatest libel on animal intelligence."*[1]

Against this conclusion Dr. Smalian[2] has raised an objection which we are now going to examine. He believes our argumentation unsound; and asks "How does Wasmann know that the *Polyergus* are at all able to feed? The basis of his argument is in concluding from the nature of the eating organs the ability to eat. And he states, that he has once seen *Polyergus* taking food independently; however, the matter is doubtful; for in the case of animals which otherwise never feed themselves but are always fed by others, it is impossible to know, whether the food they touched was actually consumed."

That Smalian should make such an objection may be explained only by assuming that he does not know the mode of life of *Polyergus* from actual observation; otherwise he would hardly have been led to attack our argumentation. Besides, he has not reproduced in full the proofs which he controverts. Indeed, it was *also* from the anatomical structure of the mouth-parts of this ant that we drew the conclusion, that no organic impossibility prevented the independent feed-

[1]) "Die zusammengesetzten Nester und gemischten Kolonien der Ameisen," p. 204.

[2]) "Altes und Neues aus dem Leben der Ameisen," p. 42.

ing of *Polyergus*. Our chief argument, however, was the *biological fact*, that the Amazons do really sometimes lap up liquid food, if *by chance* it comes in contact with the lower parts of their mouth. Dr. Smalian has undervalued this fact. Not only once, but repeatedly I saw and followed it up with a lens, how some Amazon which had pierced an ant pupa with its mandibles, *licked* up with her tongue the fluid flowing from the wound, and sometimes spent a considerable time in this occupation. Now, since the reception of food in ants generally takes place by licking, it is hard to understand, why it should be impossible to know in this case, whether the food has "actually been consumed."

Besides Dr. Smalian has failed to notice Adlerz' observations mentioned in the very passage quoted by him. Like myself, Adlerz has witnessed that the Amazons frequently lick up the moisture condensed on the glass walls of their artificial nests. That Amazons *are able* to feed independently is, therefore, an established fact which can not be done away with. Why, therefore, do they starve, when they are confined in a test tube together with some honey or some appetizing ant pupae, but separated from their slaves by which they are wont to be fed? The only possible and psychologically correct answer is: because their hunger does not compel them, like other animals, *to seek for food themselves*, but only *to beg* food of other ants by taps of their feelers. The sensitive perception of the food placed immediately before them, in spite of their feeling of hunger does no longer excite in them the natural impulse of tasting it. *With these ants*

the instinct of independent quest of food and of its independent reception has perfectly degenerated. They have become utterly dependent on their slaves. Once more we ask Dr. Smalian and other friends of animal intelligence: Is it possible that a being, which possesses but a trace of intelligence, should no longer be able to combine the sensitive perception of its proper food with the feeling of hunger? Therefore we still maintain: *A being that is physically able to eat, but has "unlearned" the habit of it, is the greatest libel on animal intelligence.*

The brilliant military talent of the Amazons is, therefore, a *merely instinctive* power, which is assisted by no individual intelligence. Just the most wonderful manifestations of the psychic life of animals, such as to a superficial observer exhibit the most striking resemblance to intelligence, upon closer inspection turn out to be evident proofs of the want of individual intelligence in animals. The brighter the light, the darker the shadows.

The *sanguine slavemakers* afford us far better ground than the *Amazons* for assuming, that in their military expeditions individual intelligence comes in for a considerable share. Some scouts of *F. sanguinea* happening upon a nest of some slave species return with the news. As soon as the favorable moment for an expedition has arrived, they go ahead showing the way. Upon arriving at the hostile nest they generally do not rush blindly to the attack, but institute a formal blockade; then, whilst one detachment impetuously forces its way to the interior, others keep a careful watch on the outside and relieve the flying

inhabitants of their larvae and pupae, which are the only objects the robbers have in view. On the part of the *sanguineas* this shows great cunning and looks very much like intelligence. If a troop of apes at war with others were to surround the forest home of their foe and if a select squadron of the assailants were to penetrate into the woods, whilst the other part lying in ambush tried to capture the fugitives, how our modern evolutionists would be delighted with these apes! Such an argument for animal intelligence they would deem absolutely irrefutable, and they would no doubt allow this to be an "intelligent stratagem." But sad to say, not apes but merely ants are skilled in such stratagems; yes, ants whose brain "can by no means compare with the brain of the higher animals!" If the development of the brain is the real cause of intelligence, then, of course, apes ought to be at least as intelligent as ants, or rather far more intelligent. In reality the reverse is the case, and thus, things look rather queer for modern evolutionism.

Let us return to the military tactics of the sanguine slavemaking ants. One characteristic feature, that of reconnoitering the nest they wish to plunder, they have in common with the Amazons. With these latter ants, according to Forel's observations, and my own, single individuals are wont to set out to investigate the site of a slave nest, and thus frequently enable the whole army of Amazons to advance in serried columns over a distance of thirty yards or more almost in a straight line to the place they had marked out. This surprising fact repeatedly observed by Forel and by myself can not be explained in any other than the above-men-

tioned way. With the Amazons, however, this system of reconnoitering cannot possibly have anything to do with individual intelligence, but only with instinctive sense faculties. This we have sufficiently proved before. Hence, the necessary conclusion is, that also in the case of the sanguine slavemakers, instinct aided by sensitive experience will suffice to explain the same fact. Therefore, to postulate intelligence proper for such an explanation would be arbitrary humanization of the brute.

The other seemingly very intelligent feature in the military tactics of *F. sanguinea* is their habit of setting out in smaller detachments more or less independent, and uniting only when one of the bands has somewhere met with stronger resistance. Since most colonies of the negro ant (*F. fusca*), which is the ordinary object of their slave hunting expeditions, are not very populous, and as the inmates generally take to their heels at the first attack of the *sanguineas,* the latter's tactics of dividing their forces is evidently appropriate to the *usual* conditions. Yet, if the assault is directed against an unusually populous and well defended nest of *F. fusca,* or against a large nest of the far more warlike *F. rufibarbis,* the same tactics frequently prove very disastrous to a considerable part of the assailing *sanguineas.* The first troop of the marauders venturing too close to the hostile nest is attacked and overpowered by the defenders, and sustains great losses, before any of the robbers are able to hurry back to call for assistance. If in the military tactics of *F. sanguinea* there were any question of intelligence or rational deliberation on the part of the single

individuals, they would surely show the prudence and precaution of previously exploring more accurately the forces of the foe they want to attack. Thus, they would not dare an assault upon stronger slave nests, until a greater number of forces were collected; then they would, like the Amazons, fall upon the hostile nest in compact masses of many hundreds or thousands at a time, and would take the hostile position by storm without any considerable loss. Why does such a change never occur in the tactics of the sanguine slave-makers? A colony of these robbers, which for many successive years has pillaged the slave nests of the neighborhood and has experienced the different resistance offered by different hostile colonies, could easily remember their respective strength and could regulate the manner of future attacks according to this knowledge. It would be all the easier for them to make an intelligent use of their former achievements and reverses, because the worker ants generally live for the space of at least two or even three years. And yet not a trace of all this can actually be found. *F. sanguinea* will forever cling to her wonted tactics of setting out in small, scattered bands, even if bloody failure should ever so often be the result. To an unprejudiced psychologist such facts bear sufficient evidence of the fact that the warfare of *F. sanguinea* as well as of *Polyergus* is guided *merely by hereditary instincts, not by individual intelligence*. Those tactics were not invented *by the intelligence of the ants:* otherwise the same intelligence of the ants would be able *to perfect* and *to develop* them. Yea more: the assumption of ant intelligence is contradictory to the

fact that those tactics are *specifically constant,* and are *specifically the same* throughout the entire territory inhabited by *F. sanguinea.*

Dr. Smalian has tried to invalidate this conclusion also. Here is his objection.[1] "It was totally wrong of Wasmann to demand,[2] that the *sanguineas* should change their tactics, instead of continually attacking in small troops and thus being easily overpowered by large troops of *fusca* or *rufibarbis.* This mode of warfare is inborn, and therefore instinctive, no less than the pillaging habit itself."

Dr. Smalian is wrong in believing that we had *in reality* demanded of *F. sanguinea* to change her hereditary, instinctive stratagems. Our demand was merely the well known method of argumentation *ex absurdo,* which the critic seems to have misunderstood. In the supposition assumed by Smalian, but rejected by us, that ants *besides* their instinct possess also a certain degree of genuine intelligence, it is perfectly justifiable to demand that this intelligence should also be *manifested* and *displayed.* If their tactics are inborn only as to their outlines, this manifestation ought necessarily to consist in *changing them intelligently* according to circumstances, and consequently in their *gradual perfection.* But there is no trace of any such advancement towards perfection, and therefore we are right in concluding: These red marauding ants have *only instinct, not intelligence.* This mode of argumentation cannot seriously be styled "totally wrong."

Wherever the sanguine slavemakers live, they will

[1]) L. c., p. 41.

[2]) "Die zusammengesetzten Nester," etc., p. 203.

follow the habit of invading nests of certain smaller species of *Formica*, and of rearing the robbed worker pupae, partly at least, as auxiliary ants for their own colony. It is, moreover, a constant characteristic of *F. sanguinea* to have rather a small number of slaves, if compared with those of the Amazons. With these latter the slaves are far more numerous than the masters, with the former it is the reverse. Likewise, the specific military tactics are everywhere equally constant with both ant species. From the Alps to England and Scandinavia, from Holland to the Caucasus, *F. sanguinea* nowhere changes her habits and customs. Even her North American sub-species (*rubicunda Em.*) shows the same instinct of slave-making, and this in the same specific form. The only difference is, that one of the two European slave species, *F. fusca*, is represented in the North American *rubicunda* colonies by a closely allied variety, namely by *F. subsericea*.[1] Since the separation of North America from Europe was completed in the Tertiary age, the enslaving habits of the *sanguineas* and their military tactics must have been essentially the same in the Tertiary as they are today. This is the most natural explanation for the specific uniformity of that instinct in the different parts of the globe. One thing, however, is certain: if the impulse of slavemaking and the specific military tactics of *F. sanguinea* were due to the intelligence of the ants, or if they were even in the slightest degree dependent on it, such a specific uniformity existing for thousands of years would be ***utterly inconceivable***.

[1] See Wasmann, "Kritisches Verzeichniss der myrmekophilen und termitophilen Arthropoden" (1894), p. 163 ff.

3. *The Pretended "Automatism" in the Psychic Life of Ants.*

Animal intelligence, therefore, has no part either in the slavemaking expeditions of ants, or in their military tactics. Yet, the application of these instincts is not mathematically uniform. They are influenced and governed by the changeable sensitive perceptions and individual conditions of the single ants, and thus great variability exists within specified limits. Those animal psychologists who, in contradistinction to the higher animals, call ants mere *"instinct automatons,"* or even mere "reflex machines," are asked to consider that the instincts of ants are neither more nor less *"automatic"* than those of dogs, apes and other vertebrates. Instances of intelligence in the true sense of the term can be discovered with the latter as little as, and even much less than, with ants. Various differences, however, of individual character, and of individual action, determined by different sense perceptions and sense experiences, occur with ants as well as with the higher mammals.

On turning over the stone or the piece of sod covering a middlesized nest of *F. sanguinea*, and thus suddenly exposing the interior to the light, we perceive all the inhabitants in tumultuous excitement. Part of the ants furiously biting and ejecting poison attack the invader; others take care of their imperilled offspring and in haste carry down the eggs, larvae and pupae to the lower chambers of the nest; other individuals of the same colony seem destitute of the chivalrous spirit of their race for the defense of

country and escape under sheltering grass tufts or clods of earth; sometimes, even, in the midst of her fighting, rescuing or fleeing comrades, a *sanguinea* presses herself to the soil motionless and, though mostly for a short time, has recourse to the instinctive trick of "feigning death;" in opposition to these, other *sanguineas*, finally, seem to be seized by a strange mixture of courage and fear, by a sort of impotent rage: not venturing to attack the real foe, they vent their spite against other objects; with sprawling feet they crawl along the ground, and with their heads bent down they furiously bite the sand or stalks of heather, attacking everything, in fact, but the finger of the great human monster that robs their nest of *Lomechusas*[1] and other favorite guests. Such scenes as the one just described I have observed hundreds of times, and am so accustomed to them, that I find them quite natural; nevertheless, they are of the utmost importance for comparing the psychic faculties of ants and those of the higher animals. Packs of wolves or hordes of apes on similar occasions could display *no greater* variability of individual character and of individual action, than such a colony of *sanguineas*. Yet, ants, we are told, are "instinct automatons," and apes or wolves are not!

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[1]) In the colonies of the North American subspecies of *sanguinea*, *F. rubicunda*, the European *Lomechusa strumosa* is represented by an allied species, *Xenodusa cava*. Rev. H. Muckermann, S. J., of Prairie du Chien (Wisconsin) has recently found also the curious pseudogyne ant form, which is due to the education of the larvae of *Lomechusini* by the ants, in the colonies of *F. rubicunda*. See Wasmann, "Neue Bestaetigungen der *Lomechusa*-Pseudogynentheorie" (Verhandl. der Deutsch. Zool. Gesellsch. 1902, p. 98-108 and Pl. II.). We shall give the figure of *Xenodusa* later on, opposite p. 181.

A dog biting the stone thrown at him, in his blind rage acts just as "automatically" as a *sanguinea* which vents her fury on the edges of a glass tube, so that you can hear the grating noise made by her jaws. And if certain individuals of an ant colony acquire through their sense-experience special dispositions and characteristics, which distinguish them from other individuals of the same colony, then they act *"automatically"* as little as dogs or apes, or other higher mammals do. Some remarkable instances of this may find a place here.

In the observation nest of *F. sanguinea* described on page 23, some beetles called *Dinarda dentata*, which I introduced, had at first been received as usual without difficulty as indifferently tolerated guests, and had even propagated in the nest. But several times I put in a little larger *Dinarda* species (*D. Macrkelii*), whose usual host is *F. rufa,* and when finally some small *sanguineas* and their slaves had succeeded in seizing and killing this beetle, which, as a rule, is unassailable owing to its wedge-shaped body offering scarcely any point of attack,[1] then a number of ants of this colony gradually took a liking to catching *Dinardas*, which liking proved disastrous also to the smaller *Dinarda dentata.* Not all the individuals of the different ant species of that colony have acquired this strange passion. Among twelve workers of *F. sanguinea* which I put from this observation nest into a smaller experimenting nest together with seven *Dinarda*

[1]) See Wasmann, *"Dinarda*-Arten oder -Rassen," in Wien. Entom. Ztg., 1896, 4th and 5th issue, and "Die Myrmekophilen und Termitophilen," p. 435 (Extr. du Compte rendu du troisième Congrès intern. de Zool. Leyden, 1896).

Maerkelii, there was but *one Dinarda* hunter. Whilst the rest remained perfectly passive towards the *Dinarda,* this one ant immediately began an active hunt. Had I not soon removed her from the small nest, she would probably have aroused in her companions the instinct of imitation for a similar persecution, a fact which I have often observed. But by removing this passionate hunter, I preserved friendly relations between the other ants in the same experimenting nest (11 *sanguineas,* 2 *rufibarbis,* 2 *fusca*) and the *Dinarda Maerkelii.* In the greater observation nest, from which I had taken these individuals, the *Dinarda* hunt, which had begun with the killing of *Dinarda Maerkelii* in March 1896, continued against *D. dentata* until November of the same year, when the ants gradually returned, but only for a short time, to their former toleration of these guests. The resuming of experiments in the following spring resulted finally in the complete extermination of *all* the *Dinardas* in that observation nest. During the following six years I never succeeded in securing the existence of even a single *D. dentata* in that nest, although in nature this beetle is indifferently tolerated in all *sanguinea* nests! The psychological importance of these phenomena has been pointed out already in our discussion on the different forms of learning in the animal kingdom.[1]

Another strange fact quite irreconcilable with the "blind automatism" of instinct is the behavior of ants regarding the *number* of *Dinardas* and other beetles,

[1]) "Instinct and Intelligence," etc. (Herder, St. Louis, Mo., 1903), p. 157. Also "Die psychischen Faehigkeiten der Ameisen" (Stuttgart, 1899), pp. 84, 88, 93.

which I introduced into that observation nest during my experiments on the international relations[1] of ant guests. If previously no *Dinarda* had been present for some time, one or two of *D. dentata* were often quietly received and tolerated for weeks. But as soon as I would add some more beetles of this species, the persecution began, at first against the newcomers, and finally, the passion of hunting having been aroused, also against the old ones, until all were seized and devoured. Thus the ants seem to have been led to this persecution not so much by the perception of *one beetle by itself*, but rather by that of their *increasing number*. It was this that aroused their hostility.

The *sanguineas* of the same observation nest once manifested unmistakably that they desired only a limited number of their genuine guest *Lomechusa strumosa*, otherwise so dear to them. In September, 1898, I had captured in a *sanguinea* colony[2] 116 beetles of that species and placed 30 of them in my observation nest. After a few weeks, however, 19 of them had been driven out of the main nest and were confined in the empty annex, where they all perished, being isolated from their nurses, whilst the remaining 11 were for the whole winter carefully tended by their hosts and very often fed and licked by them. The ants, therefore, had not changed their behavior toward

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[1]) "International relations" I term the relation of ant guests to different colonies and different species of ants, which are hostile to each other.

[2]) No. 191 of my statistical map of the *sanguinea* colonies near Exaten. In treating about the education of the *Lomechusa* larvae by *F. sanguinea*, I shall communicate more detailed observations regarding this colony (in the last chapter, number 3, "Adoption Instincts in the Animal Kingdom").

the *Lomechusas as such*, but merely toward their *excessive number*, which became disagreeable to them. Perhaps they were unable to feed so many beetles and had therefore expelled half of them. At any rate, such phenomena prove to a certainty that ants are not to be regarded as mere "instinct automatons" or "reflex machines." We must ascribe to them sensile mental faculties, which by way of different perceptions and representations cause great variability in the display of their instinctive impulses. But, *beyond this, nothing* is required to explain satisfactorily the psychic life of the vertebrates. Hence, there is no need of "animal intelligence," neither in the case of ants nor in that of the higher animals.

A beautiful instance of how sensile experiences of ants lead them to acquire certain individual peculiarities of character, I witnessed in the case of a *F. rufibarbis* of the same mixed colony. She was a worker, easily distinguishable from the others by her small size. She used to visit regularly the glass bulb of the feeding tube (see diagram, p. 23), where she would lick the honey or sugar in order to supply the other ants in the main nest from the sweet juice stored up in her crop. Although *F. rufibarbis* belongs to a very irritable and pugnacious species, yet this ant had gradually become so *tame* that she would allow herself to be fed from my hand. As soon as I removed the cork of the glass bulb, she would come out and look for food on the outside. I would then present to her a needle dipped in honey. At first she darted back, but after a few seconds of hesitation she would approach, examine the needle with her feelers and

lick off the honey. Later on I placed the honey on my finger. The ant had already become so tame that she was not in the least disturbed by the odor of my finger, whereas others would have been provoked to a fight or would have been greatly alarmed. She would quietly lick off the honey and then, without resisting or trying to flee, allow herself to be seized with a pincette by one of her legs and placed back in her nest. This goes to prove that *ants also are tamable* in spite of their excitable nature. The tamableness of ants, like that of higher animals, is due to their possessing the powers of sensitive perception and imagination, upon which the intelligence of man acts to accomplish his purpose.

Against this parallelism an objection was raised by Mr. Bethe.[1] To tame an ant, he says, takes weeks and months; but a dog may be tamed in a few days; therefore the above mentioned fact presents no proof of the existence of psychic faculties in ants! Whether Mr. Bethe will succeed each time in taming a vicious dog within a few days, is rather doubtful. Nor is it at all true, that it takes several weeks or months to tame an ant, e. g., a *F. fusca* or *rufibarbis*, which are especially suitable for such experiments. It is but required to mark a certain individual which comes regularly to the feeding tube. If you are very careful not to frighten the animal, it is possible to train it in a few days, in the manner described above. But if you wish to reckon the time needed for taming an ant by beginning with the day on which she was

[1]) "Duerfen wir den Ameisen und Bienen psychische Qualitaeten zuschreiben?" (Bonn, 1898), p. 23.

first deprived of her freedom and placed in the artificial nest, then the same method of calculation must be applied in the case of the dog. Mr. Bethe should not, therefore, take for his experiments a domesticated dog, but he would have to operate upon a newly-captured animal of the *wild* dog species. Then let us see, which would take longer, to tame a wild dog or to tame a wild ant!

There are several other interesting analogies between the psychic life of ants and that of dogs. A small dog, as long as he is in the company of his master or of some stronger comrade, will not be afraid to meet a rival, whom otherwise he would try to avoid. The same is the case with the small black negro ants (*F. fusca*) when they are in company with *sanguineas.* In their own colonies they are generally cowards. As soon as their nest is disturbed, they flee and try to hide their young, but when they are slaves in colonies of *F. sanguinea,* they are the bravest defenders of the mixed colony, as I have often experienced to my cost. Just as in the mixed colony of *F. sanguinea* the instinctive courage of *F. fusca,* which is otherwise so cowardly, is to be explained psychologically from their perception of the great number of valiant companions and their consequent sense of solidarity, without supposing any reasonable deliberation on their part, so also are the different degrees of courage found in different colonies of the sanguine slavemakers to be accounted for. If a numerous population inhabits a rotten fir stump, on the surface of which we find some of the ants running about, a gentle kick will at once call forth a whole army ready for the fray. In a

moment the whole surface of the stump is covered with thousands of ants furiously hurrying to and fro. But, if the colony is weak, the same kick, which at other times calls forth an army, will have the contrary effect. The ants which just before were running about the surface, disappear through the entrances of the nest as if by magic, and deathlike quiet succeeds. If in ants this appropriate estimation of the strength of their own colony is characterized as instinctive,— and this is, no doubt, the only correct expression,— then, similar occurrences among higher animals should also be credited to instinct and not to intelligence.[1]

Yet, the courage of individual ants in a colony is dependent not only on the perception of the great number and courage of their comrades. In populous colonies also of warlike species such as *F. sanguinea*, there will always appear considerable differences in individual courage, as we have shown above. Sometimes even single, isolated individuals make head against a numerous foe. Such an example of "heroism" scarcely ever equaled by dogs, lions, and tigers, was once witnessed by Rothney[2] in Bengal. A middle-sized worker of a large black ant species (*Cam-*

[1]) Forel (Un aperçu de Psychologie comparée [1896], p. 25) mentions an instance, where a very strong colony of *Camponotus ligniperdus*, when fighting with *F. pratensis*, showed a more warlike spirit than is the custom with the ordinary colonies of that species. We fully agree with Forel if he infers therefrom the existence of "plasticity" in the psychic faculties in ants. Our own observations mentioned above prove the very same. Yet, in considering this plasticity of the sensitive powers of cognition and appetite to be essentially identical with human intelligence, he is entirely wrong, as we have shown in a former publication, "Instinct and Intelligence in the Animal Kingdom."

[2]) "Notes on Indian Ants," p. 349 (Transact. Entom. Soc. London, 1889).

ponotus compressus) attacked quite alone a whole colony of small red ants (*Solenopsis geminata*). Without moving from her place she remained before the entrance of the *Solenopsis* nest from 4:30 p. m. until night, seized the ants with her jaws as they came out, and bit them in two. At last she was overpowered by superior numbers, and after having killed 150 or 200 of her foes she paid for her temerity with her life. We leave it to the modern worshippers of animal intelligence to raise a monument to the memory of this insect Leonidas.

We need not, however, go as far as Bengal to find such examples of "heroism" of single ants. There are plenty of them in the heaths of Germany and Holland, and also in North America. During hot weather strolling workers of *sanguinea* will frequently enter into a fierce battle with colonies of *Lasius niger* or *Tetramorium caespitum* living in the neighborhood, till at length, when too many of their opponents have clung to their legs, they fall victims of their own foolhardiness. A scene, more harmless indeed, yet psychologically not less remarkable, I observed near Exaten on the afternoon of August 15, 1894. A large worker of *F. sanguinea* amused herself for a quarter of an hour by blockading all alone, a colony of the small, red stinging ants (*Myrmica scabrinodis*). She lurked about the entrance, seized by the neck one red ant after another, as they came out, carried them quickly to a distance of several inches, and dropped them in order to be back again at once at the entrance to seize the next customer. The *Myrmicas* scarcely attempted any resistance, although several dozens of them were

in and around the entrance. Only one or two tried to get hold of the intruder by one of her legs, but without success. Of course, their horny (chitine) armor protected them sufficiently against the jaws of the *sanguinea*; all the more, as the latter did not allow herself time to pay special attention to her single foes. It was exceedingly amusing to see the indefatigable zeal and hurry of the large ant getting hold of the small ants one after another and carrying them away, after which they slowly crawled home again. It is hard indeed to say what induced the *sanguinea* to engage in this odd kind of skirmish. Perhaps it was mere love of fighting. That she released the single *Myrmicas* so soon, might be explained by her fear of the sting, with which these ants are provided. Yet, it is more probable, that the marauder took a fancy to the entrance of the *Myrmica* nest, and on this account tried to expropriate the inhabitants. Of course, her labor was no more successful than that of Sisyphus, because she did not carry the ants further than a few inches from the nest, and, besides, the number of ants coming out of the nest had no end; but this did not seem to affect her in the least.

It would be ridiculous, arbitrarily to humanize such instances and to suppose all possible kinds of "intelligent purposes" on the part of the ant, as is customary with popular psychology. Yet, on the other hand, it cannot be denied, that "mechanical automatism" of instinct will never explain them. The only satisfactory solution psychology can give, is to ascribe to ants sensitive powers of cognition and appetite, which, under the influence of exterior sense per-

ceptions and individual dispositions, are the principle, from which these various, spontaneous activities result, with no difference as to whether the actions are performed by ants, or by dogs and apes.

The phenomena described above may be classed among the "sports" or "games" of animals, as Groos[1] terms them. The facts recorded deserve these names perhaps just as well as the sports and games of the higher animals; only, it is generally much more difficult to ascertain the nature of given facts in the case of ants. Among the heaps of ants that gather on the surface of the ant-hills of *F. rufa* and *pratensis,* as also in my artificial nest containing *sanguineas* when exposed in spring to the warm rays of the sun, I have repeatedly observed instances of harmless wrestling, beginning with and accompanied by lively and playful movements of the feelers. This behavior of the ants seems to be due to a resuscitation of their powers and also to an excess of muscular energy after the winter's rest.

Forel (Fourmis de la Suisse p. 367) has made similar observations with *F. pratensis,* and Huber[2] with *F. rufa* and *pratensis.* I cannot consider these games

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[1]) "Die Spiele der Tiere" (1896), pp. 125 and 135. By the way, Groos here and elsewhere was too confident in trusting the authority of Buechner, who has not unfrequently misrepresented Huber's and Forel's observations to suit his own purposes of humanizing the brute. Forel, in the Études myrmécologiques, has expressly protested against Buechner's misrepresentations of his observations. The book of Groos contains in general a great many statements of doubtful value, in spite of the critical standpoint from which the author maintains to view the facts.

[2]) Since *Huber* in his *"Recherches,"* p. 151, does not say whether he means the *fourmi fauve à dos rouge* or that *à dos noir,* we are hardly able to decide which ant it is.

of ants as an "evident reaction against instinct," as Forel did, at least formerly, in his book mentioned above. They are instinctive no less than the romps and scuffles of young cubs, or the frolics of lambkins. They are due, I suppose, to the natural impulse of exercising the muscles, which is pleasurable to animals as well as to human beings. At any rate it would be wrong to ascribe them to intelligence, either in ants, or in the higher animals.

The erroneous doctrines about the "absolute blindness" and the "mechanical automatism" of instinct, which are still current, have done a great deal towards making animal intelligence appear almost indispensable. Assuming instinct to be a mere reflex mechanism, it was of course impossible not to declare as "intelligent activities" all the manifestations of the instinctive faculties, which are determined and influenced by individual sense perceptions and sense experiences. This, however, as we have shown above,[1] is an altogether uncritical procedure. The study of ant life enables us to determine more correctly the nature of animal instinct, this being the case especially with *F. sanguinea,* which in point of so-called "intelligence" may fairly rank with the highest vertebrates.

4. *Slavery among the Sanguine Slavemakers.*

The custom prevalent among these red ants of robbing and rearing slave pupae, is of course *entirely instinctive.* Even our scientific opponents acknowledge that it would be nonsense to explain it as an intelligent

[1]) "Instinct and Intelligence," etc. (Herder, St. Louis, Mo.), Chap. II and III.

invention of some colony of *sanguineas,* transmitted by inheritance to all the descendants of the species. Forel, Emery and Smalian fully agree with our trenchant condemnation[1] of Buechner's manner of humanizing the "slavery" of ants. It does not seem impossible, however, that for the actuation of this instinct there should be needed special psychic impulses produced in the young ants by the example and the feeler language of their older companions. Yet, this assumption is scarcely probable; for the formation of new colonies is undertaken, as a general rule, by single impregnated females; but the females of *F. sanguinea* are devoid of the enslaving instinct, and cannot, therefore, induce others to manifest it. Yet, since it is the general opinion, that *tradition and instruction* aid the exercise of the social instincts in these insects, and that the high perfection of their community life receives thereby its full explanation, we will examine whether in view of the facts this opinion is still tenable.

It is true, in ant communities the *instinct of imitation* plays a great part, as we may gather from several observations recorded above. By the example and the taps of the feelers of their older comrades the younger ants are often induced to actions, which otherwise, at least under the same circumstances, they would not have performed. In this regard, as in fact in the other salient features of the psychic life of animals, ants and the higher animals agree in all the essentials; for, in the latter also the so-called lessons given to the young by their parents consist only in exciting instinctively in the young the faculty of imitation by the exam-

[1]) "Die zusammengesetzten Nester," p. 182.

ple of their parents. If we interpret "tradition and instruction" *in this sense,* it must be acknowledged that they aid in the exercise of the hereditary instincts both in ants and in the higher animals. But, on the other hand, it is equally obvious, that in this case the terms "tradition" and "instruction" mean something very different from what modern animal psychologists wish to insinuate; for, in our case, they do not imply any *intelligent* communication of knowledge, but only the instinctive excitation of the imitative faculty.

But in the communities of social insects not even the encouraging example of the older companions is *necessary for the first actuation of the young workers' instincts.* We have ascertained by experiments, that precisely the most remarkable and apparently most intelligent habits of the sanguine slavemakers, namely their rearing of slaves and the hospitable care bestowed by them on the beetle *Lomechusa strumosa,* are *merely hereditary instincts,* for the exercise of which no kind of "instruction" on the part of the older ants is needed.[1] To prove this we formed a special colony of "self-taught" young workers of *F. sanguinea,* by placing in a glass filled with a sufficient quantity of earth a number of ants that were newly developed from their cocoons in my artificial nest. These self-taught ants not only performed all the works required for building their nest, just as the other individuals of their species, but they also followed the very same line of conduct in nursing their young and even in dealing with strange worker pupae which I introduced into their

[1]) L. c., p. 202, and "Die internationalen Beziehungen von *Lomechusa strumosa,*" in the "Biologisches Centralblatt," XII (1892), 592.

nest. The pupae of *Lasius niger* they would either devour or throw away, whereas those of *F. rufibarbis* were reared by them as auxiliary ants for their colony. A *Lomechusa strumosa* which I put in, was immediately received like an old acquaintance, licked and fed, just as is the custom in the other colonies of *F. sanguinea*. In the face of such experiments the beautiful theory of tradition and instruction among ants vanishes into thin air.

That the older ants "lead their newly born comrades about the nest and train them to a knowledge of domestic duties, especially in the care of larvae," is a fable originated by Buechner[1] and unfortunately taken up on his authority even by Romanes[2] and other modern animal psychologists. The truth is, that the newly developed ants are as yet the objects of special care and protection on the part of the others, as remarked already by Huber. Being as yet rather helpless, they are still, as it were, considered as "wards."

The same applies to bees. In their case also the instruction said to be given by the old workers is a mere fancy, arising in the brain of some anthropomorphizing observer. Already Réaumur in his classical work *Histoire des Insectes*[3] remarks: "Scarcely have all the parts of the body of a young bee become sufficiently dry, scarcely is she able to move her wings, when she is already acquainted with everything she will have to do in the whole course of her life." He goes on to relate a few observations showing, that

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[1]) "Geistesleben der Tiere," p. 62.
[2]) "Animal Intelligence" (6th ed.), p. 59.
[3]) Tom. V. part II, mém. XI, p. 278. Amsterdam, 1741.

young bees from the very first day are as well able to use their instincts as are their seniors. Of late some experiments have been made by Kogevnikov[1] and Butkewitsch[2] on self-taught young bees. The results were practically the same as in the case of the self-taught ants. It was found that in the workers the building of combs and the nursing of the young, and in the queens the love of combat were hereditary instincts, utterly independent of experience and instruction. Besides Charles Janet's excellent observations on hornets[3] show, that social insects are ruled only by hereditary instincts, excited to their natural manifestation by the very first experiences of the young individual. The impulse of imitation with its various incitements is only a secondary factor. This is the truth regarding the captious shibboleth of "instruction and tradition" in insect communities.

No doubt, therefore, is left as to the fact that the slavemaking habits and the military tactics of the *sanguineas,* just as the social life of ants in general, are due to *instinct only, not to individual intelligence.* Yet, this instinct is not an absolutely blind impulse, but is suitably modified according to the wants and purposes of a given colony. A blind impulse to rob and to rear slave pupae would be expected to impel *sanguinea* colonies to rob the more slaves, the stronger and more numerous they are themselves. In the most populous nests we ought to find the greatest number

[1]) "Zur Frage vom Instinct," in "Biolog. Centralbl.," Vol. XVI (1896), No. 18, pp. 657-660.

[2]) "Russisches Bienenzuchtblatt," April,1896. See Kogevnikov l. c.

[3]) "Mémoires de la Société Zoologique de France." T. VIII (1895).

of auxiliary ants. *In reality the very reverse happens.* The most populous *sanguinea* colonies do not contain the relatively *greatest* but the relatively *smallest* number of slaves. We formerly (in "Die Zusammengesetzten Nester" p. 50) alluded to this fact, which shall now be explained and proved at greater length. In order to show the connection between the rearing of *Lomechusa strumosa* in the *sanguinea* nests and the education of a strange, crippled kind of workers, the so-called pseudo-females or pseudogynes,[1] I drew up an accurate statistical map of the *sanguinea* colonies in the neighborhood of Exaten. It comprises 410 colonies with more than 2,000 nests.[2] Regarding the number of slaves, the statistics showed that in most colonies the masters were from three to six times more numerous than the slaves. The most populous colonies contain scarcely 50 to 100 slaves, sometimes even less or none at all. In the middle-sized or weaker colonies, however, the absolute number of slaves amounts in most cases to several hundred. The average proportion of masters and slaves in the most populous colonies is from 100:1 to 10:1, in the middle-sized and weak colonies, however, from 3:1 to 1:1. Nor are these the ultimate limits assigned to the number of slaves found in the nests of these ants. In May, 1890, and from 1896 to 1898 I found near Exaten several strong *sanguinea* colonies without any slaves.[3]

[1]) "Die ergatogynen Formen bei den Ameisen und ihre Erklaerung," in "Biolog. Centralbl.," Vol. XV (1895), Nos. 16 and 17.

[2]) A colony of *F. sanguinea* not unfrequently embraces several nests, often one or more metres distant from one another, inhabited all at the same time or alternately.

[3]) To similar colonies of *F. sanguinea* of the race *rubicunda* in North America we must probably refer the *F. sanguinea* race *aserva* of Forel, who described it lately from Toronto (Canada), (Ann. Soc. Ent. Belg. XLV, 1901, p. 395).

A similar colony I recently detected near Luxemburg, 1904. On May 23, 1889, I met with the opposite extreme, namely, a very weak *sanguinea* colony, in which the slaves were about twenty times more numerous than their masters. These extreme cases are, however, very rare. Besides, it is plain that the number of slaves in different colonies changes every year; and lastly, the number of slaves in the nests of the sanguine slavemakers depends also on special, local circumstances. Where slave nests are very numerous, e. g., in groves of birches and oaks, there more slaves will be found in the *sanguinea* nests than on the open heath, where *fusca* nests are very scarce. Yet, *ceteris paribus,* we find the constant law, that in a given *sanguinea* nest, the number of slaves and that of masters is not in *direct* but in *inverse* proportion. My observations of *sanguinea* nests in Dutch Limburg, Rhineland, Vorarlberg, Bohemia and Luxemburg, everywhere confirmed this law.

How is this remarkable difference between the colonies of *sanguineas* and of Amazons to be explained? The latter possess the more slaves, the more populous the colony; with the former we meet the reverse. This difference is explained by the fact that *F. sanguinea* is not, like the Amazons, essentially dependent on her slaves, but rather regards them, as it were, as a secondary complement of her own communities. The *sanguineas* rob and rear only as many slave pupae, as is suitable for their colonies. Weaker colonies thus feel greater need of supplementing their own deficiency by adding auxiliary forces, whereas stronger colonies do not feel the same necessity; so they regulate their

action according to their perception of this deficiency. It is true, the smaller number of slaves in more populous *sanguinea* nests may partly be due to another circumstance, viz., that in the latter a greater percentage of robbed pupae is eaten than in smaller nests. Nevertheless, this circumstance is far from explaining, why in the weakest colonies of this marauding ant the number of slaves even exceeds that of the masters. The only way of accounting for this fact is to assume that these colonies try to *strengthen* their forces by the greatest possible number of auxiliaries.

To perceive this necessity of increasing their numbers does not go beyond the limits of the instinctive powers of ants. A very interesting case of this kind was observed by me both in the summer and the fall of 1898 in my artificial nest of *F. sanguinea,* already repeatedly referred to. During my absence, extending over several weeks of July and August, the nest had been badly cared for and had repeatedly dried up; consequently many workers of *sanguinea* and the greater number of the old slaves had perished. Meanwhile new auxiliary ants (*F. rufibarbis*) had been reared from cocoons which I had given to the *sanguineas.* Now, I observed in the course of September, that new clusters of eggs, laid by the two queens, made their appearance in the nest, and that a number of larvae were reared, some of which were conspicuous for their rapid development. This is an exceptional case, generally not occurring in *sanguinea* colonies during autumn. In October and the first part of November I was absent again. On my return I found, to my great surprise, that in place of the *two*

wingless queens there were now *four* of them in the nest. This shows that the ants had reared two new queens from the eggs which had been laid in the fall.[1] The mortality prevalent in their colony during summer must have caused this exceptional conduct. On duly considering such facts, it can hardly be found strange that *sanguineas* try to make up for the deficiency of their numbers by robbing and rearing the pupae of other ants; for the enslaving habit serves them as a secondary means of increasing their colonies.

The manner, too, in which the *sanguineas* make their choice between the different castes of alien *Formica* pupae, confirms the above explanation; for this phenomenon is understood only by referring it to their desire to augment the forces of their colonies. It is evident that the rearing of slave pupae is not governed by a "blind instinct of education," inducing the ants to transfer all their care to the strange brood; for they consume the male and female pupae of strangers, or kill the sexual ants as soon as they leave their cocoons, whereas they adopt, at least partly, those pupae of strangers, which will develop into workers. They distinguish, therefore, by olfactory perceptions between their own pupae and those of strangers, and they likewise distinguish between the different castes of the latter. Hence, we are compelled to maintain: *the sanguine slavemakers do not rear the worker pupae of strangers, because they are unable to distinguish them from their own, but because they aim at augmenting the number of their own workers by*

[1]) The two old queens were still living in the spring of 1900, and laid eggs in spite of their age of almost ten years. One of them died last year (1903), thirteen years old. The surviving queen (fourteen years old) I set at liberty with the rest of the workers in spring, 1904.

adopting strangers as auxiliaries. Of course, they are far from having an intelligent knowledge of this purpose. It suffices that, on account of the actual need of workers, the instinctive impulse of the ants to bring up fresh workers is aroused with greater intensity and, for this reason, extends to other *Formica* cocoons. And this is the only explanation admissible, for we have proved above, that with *F. sanguinea* slave-holding is not due to experience or instruction, but to hereditary instincts.

Is there anything in the social life of higher animals, which can rival this strange phenomenon? We know of nothing. If there had been, then Darwin, Ziegler and other evolutionists would not have failed to turn it to account, and to appeal to it as convincing proof of the "quasi-human intelligence" of higher animals; for, if an association of animals perceives the necessity of increasing its strength by adopting auxiliary forces, and under the influence of this perception actually adopts them, then this action proceeds from a motive originating in sensitive experience, and is therefore *intelligent*, at least according to modern animal psychology. Nevertheless, ants are said to be "instinct automatons," but higher animals are not! And this again shows, how utterly untenable, on the one hand, is the modern notion of intelligence, and, on the other, how foolish the attempt to place the "intelligence" of the higher animals on a far higher level than that of ants.

Bethe,[1] indeed, has of late made an attempt to explain, in a very simple manner, the proportion

[1]) "Duerfen wir den Ameisen und Bienen psychische Qualitaeten zuschreiben?" p. 69.

between the number of masters and of slaves found in colonies of *F. sanguinea.* "The correlation," he says, "existing between the numbers of masters and slaves is as little owing to psychic processes, as the numerical correlation existing between mice and buzzards, or between certain butterflies and cuckoos." Yet, it is hard to see what is proved by this comparison, unless it be the very contrary of what Bethe pretends to prove; for the more mice there are, the more buzzards will come to the spot, and the more butterflies, the more cuckoos; however, in the case of *sanguinea* colonies *just the reverse* takes place, namely, the more masters there are, the fewer slaves they have in their colonies!

As the *sanguineas* accommodate themselves to given circumstances regarding the *number* of their slaves, so also regarding their *species.* Their favorite slave species is *F. fusca.* This black ant is found as auxiliary in the greater number of the above mentioned 410 *sanguinea* colonies near Exaten. In 25 colonies the place of *F. fusca* is taken by a different species, viz., *F. rufibarbis;* 17 colonies have both species. Near Feldkirch, in Vorarlberg (Austria), I found side by side with colonies which had the above mentioned slaves, others with *F. cinerea,* or with *F. fusca* and *cinerea.* The latter species does not occur in Dutch Limburg, and for this reason no *cinereas* are found there as slaves in *sanguinea* nests. Yet, the fact that the *sanguineas* occasionally invade weak colonies of the large hill ants (*F. rufa* and *pratensis*) to rob their pupae and to rear them as auxiliaries, proves that their "blind instinct" does not force them to rob

automatically a certain, fixed species of slaves. In May, 1890, I found near Exaten such a "natural, abnormally mixed" *sanguinea* colony containing, besides *F. fusca*, a considerable number of *F. rufa*. This colony has since disappeared; for on my return after a two years' absence I looked for it in vain. Since 1895 I found in the same neighborhood of Exaten four other natural, abnormally mixed colonies of *sanguineas*. One of them (col. No. 66) had only *F. pratensis* as slaves; the second (col. No. 105) *F. rufo-pratensis*, a variety intermediate between *rufa* and *pratensis*, with *F. fusca;* the other two had (col. Nos. 84 and 247) *F. pratensis* and *fusca*. Three of these colonies, therefore, possess besides the ordinary species of slaves, an extraordinary one. In August, 1891, I came on the Arlberg pass (1,800 m.) across a *sanguinea* colony that had *rufas* as slaves. Forel[1] has long since recorded some very interesting instances of natural, abnormally mixed colonies of these marauding ants in Switzerland, namely a *sanguinea* nest with *F. pratensis* as slaves, and another with *rufa*. The *sanguineas* therefore display the same peculiar universality and the same gift of suitable adaptation in their enslaving habits both in Holland, and in Tyrol and Switzerland; those qualities are due to that specific nature of their sensitive cognition and appetite, which we call "instinct."

The above observations on these "natural," mixed colonies have made it plain enough, why the *sanguineas* accept the worker pupae of different, alien

[1]) "Études myrmécologiques en 1875," p. 25 (57) and en 1886, p. 9 (139).

Formica species and rear them as slaves even when they are given to them by man. Forel[1] and myself have made various experiments on this point with artificial observation nests kept in a room and with nests found in free nature. It may suffice to mention one of them. In the summer of 1895, several times in succession I took a large bag of worker cocoons from a huge ant hill of *F. rufa* and emptied it in the neighborhood of a densely populated *sanguinea* nest,[2] which had but a few *fuscas* as slaves. In a few minutes the sanguine ants had put to flight the thousands of *rufas* contained in the bag with the cocoons and parts of the nest, had snatched the cocoons from the mouths of the fleeing *rufas* and began to ransack whatever I had brought of the hostile nest. For hours after, hundreds of these white "ant-eggs" were seen wandering from the plundered nest to the den of the robbers and mysteriously disappearing therein. By far the greater number of the *rufa* cocoons were reared by the sanguineas. This artificially mixed colony numbered, in 1896, about 5,000 *sanguineas* and 8,000 *rufas*. The latter were generally busy building on the surface of the nest and had soon given it the appearance of a true *rufa* nest. At the least disturbance, however, thousands of light-red *sanguineas* would dart out from the interior to defend their common home; and thus the supposed *rufa* nest was turned into a *sanguinea* nest as if by magic. Because ants know no other home than that in which they have developed from the cocoon, these *rufas,* although they are in the majority,

[1]) "Fourmis de la Suisse," p. 258 ff.

[2]) Colony No. 39 of the statistical map.

will faithfully serve their ravishers and natural enemies, without "reflecting" on how they happened to get into this unusual society.

I have had in my room, for the last twelve years, an artificial nest of *F. sanguinea* (see p. 23). This colony adopted as slaves the workers of all the *Formica* species to be found in Holland, viz., *F. fusca, rufibarbis, rufa* and *pratensis*. The "slaves" have developed from cocoons, which I had put into the nest during recent years. In free nature the same *Formica* species are found as slaves in the *sanguinea* nests, but only one or two of them at a time; in this nest, however, they were all united to form one colony under the suzerainty of *Formica sanguinea*.

Yet, this *"suzerainty"* and *"slavery"* in the mixed colonies of ants is altogether different from what the same terms imply when applied to human society. Only authors like Ludwig Buechner might be found guilty of confounding ideas to such a degree. There is *perfect equality* among all the workers of a *mixed* colony, no less than among all the workers of a *simple* colony. The very same "constitutional laws" are in force both for masters and slaves; in other words, the uniform "nest smell," which adheres to all ants reared in the same nest, serves them to recognize one another as members of the same ant community, the differences in *species* being totally disregarded. The so-called slaves live entirely free in the nest of their ravishers, that is to say, they live according to the same innate instincts which would have formed their rule of conduct at home; they work for their ravishers, supply them with food and rear their off-

spring, as if they were in their *own* colony. They are called *"slaves,"* only because they are reared from robbed pupae, live in the nests of strangers and work for them. On the other hand the *sanguineas* are called *"masters,"* only for the reason that they have robbed the pupae of an alien species, from which their auxiliaries originate; and besides, because these mixed colonies contain not workers only of *F. sanguinea,* but also their males and females, whereas the slave species is represented only by workers. This is why in mixed colonies the propagation of the masters is ensured but not that of the slaves.

Therefore it is downright nonsense for Buechner to place slavery among ants and human slavery on essentially the same level. By virtue of his intelligence, man possesses the power of *reflecting* on his origin and social position; he is gifted with *self-consciousness*; accordingly he considers slavery as an unjustified deprivation of freedom, a state of humiliation, a degradation of his human dignity. With ants it is different. They have neither intellect nor self-consciousness, and are thus incapable of pondering over the obscure question "whence" and "whither." As auxiliary ants they follow their social instincts just as well as in a nest of their own species: they are as free and independent as any other ant on earth. Hence among slave ants there are no runaways, no revolutionists, no conspirators, no anarchists. He, who seriously points to the complete socialism and communism of mixed ant colonies as models for human socialism and political economy, is sadly in need of a nerve specialist.

On the other hand, in opposition to those animal psychologists who rank the "mental faculties" of the higher vertebrates incomparably above those of ants, it is necessary to emphasize the fact, that no association of apes or other mammals can compare, as to psychic faculties, with the mixed colonies of ants, especially with the *sanguinea* colonies. The rearing of the offspring of closely allied species as useful members of their own society is an arrangement never found with apes. The wars, therefore, and military expeditions of ants addicted to this practice rank much higher than the wars of baboons and other apes. True, slavery among ants is based only on instinct, not on intelligence. But anything higher than instinct is not found in the societies of higher animals either. In fact, the development of their social instincts is rather far inferior to that of ants.

5. *Other Wars and Alliances of Ants.*

The slavemaking expeditions of the Amazons and *sanguineas* are indeed the most interesting; but by no means the only wars waged by ants. There are many other feuds and skirmishes, both between ants of different species and between different colonies of the same species. Most of these feuds are caused by disputes about subterranean or open-air boundaries, calling for settlement "at the point of the sword." When underneath a large stone there is a "compound ant nest," i. e., when two or more different species have built their respective nests in close proximity, they are separated by walls of earth. No one ventures into the neighboring realm, and woe to him, if he does;

he is seized and put to death. As a rule, only the dwarfish, yellow, thieving ants (*Solenopsis fugax* in Europe and *S. molesta* in N. America), may pilfer in the neighboring nest of a larger species. The small, black lawn-ant (*Tetramorium caespitum,* in Europe and N. America) will occasionally do the same. These thievish little ants are in the nests of larger species, what rats and mice are in the abodes of man.

To return to the "compound nests." By turning over the stone, under which several different ant species live side by side in separated nests, the partitions are suddenly removed, and a fierce battle ensues with great loss of life on both sides. The engagement frequently continues for a considerable time after the stone has been replaced. Only after the boundary-lines have been perfectly restored, is there again peace between the neighboring states. Sometimes on such occasions it becomes evident that one colony is numerically far superior to the other. In this case we notice that the weaker is simply driven out of his nest, which is then entirely or in part occupied by the victor. Thus the war ends with the "territorial expansion" of the more powerful state.

Above-ground disputes between neighboring ant colonies, not infrequently lead to fights, which last for weeks or even months, interrupted by longer or shorter periods of "armistice." These battles are most obstinate and bloody between different colonies of the small, black lawn-ants (*Tetramorium caespitum*). This species is found everywhere, frequently with hundreds of thousands of earth-nests within a square mile. On July 8, 1886, I saw a regular battlefield on

a sandy road near Exaten. It fairly swarmed with fighting lawn-ants. The combatants numbered thousands and they covered a space of about 70 cm. by 8 cm. So dense was the battle-array that individuals could scarcely be distinguished in the mass of warriors. They formed irregular clusters of from 2 to 14 individuals all clinging together with their mandibles and making liberal use of their stings. The summer heat had inflamed the rancor of the two tribes, long living too close together. The battle probably ended with the expulsion or the utter extermination of one of the communities.

Among men civil wars are generally the fiercest and bloodiest. The same may be said of the wars waged between different ant colonies of the same species. However, only the "heat oppressed brain" of Buechner or Brehm could detect a closer analogy between these phenomena. As the males of certain birds fight for their breeding districts, nor allow other families of the same species to settle there,[1] so ant colonies are wisely compelled by the laws of nature to regard the district about their nest as exclusively their own, on which no other colonies of the same species are suffered to encroach. Otherwise, their wants being equal, their food supplies would become scarce. Hence arises an instinctive hatred between different colonies of the same species; whereas colonies of different species whose mode of life and means of sustenance are different are admitted much more easily. The preservation of the species necessitates the fiercest struggles for existence between

[1] Altum, "Der Vogel und sein Leben," (6th ed.), p. 128 ff.

tribes of the same species. Not inordinate greed in the individuals nor imperialistic tendencies in the tribe, but higher, natural laws are the mainsprings of these "civil wars" among ants. The poet indeed, may exclaim: "There is room on earth for all" (Schiller); but even in the life of ants this beautiful saying is often correct only in theory.

Many more accounts of wars and battles among ants could be mentioned; but we cannot enter upon them here, since our principal purpose is to call attention to a few points of comparison between the "intelligence" of ants and that of higher animals and of man. It remains only to be stated that the wars of ants sometimes end in an *"alliance,"* that is to say in a peaceful union of the combatant tribes into one constitutional body. These alliances are usually formed between *Formicas* of the same or different species, but are most frequent between different colonies of *sanguineas.* From Forel's *"Fourmis de la Suisse"* and from my own observations (see Die zusammengesetzten Nester p. 146-157) many instances might be selected. The chief conditions for such alliances between hostile ant colonies are, that the two opponents be closely allied in species, that they be almost equally populous, and lastly that they be forced to live in close proximity and are thus unable to avoid each other. Under such circumstances their original skirmishes give way to mutual toleration and finally to friendly intercourse. A superficial observer, of such occurrences, might be led to believe that intelligent reflection had caused the animals to overcome their instinctive aversion. He might conclude that

ants reason thus: "Why this useless shedding of blood? Let us not exterminate each other but live in peace; our differences are not so great that we cannot come to terms!" Yet, there is not a shadow of proof that ants entering into an alliance reason in this manner. The phenomenon, which is indeed singular enough, can be explained more simply and naturally from the laws of instinctive sensation, with special regard to the feeler sensations. Especially with the *Formica* species, and among these, most of all with the highly endowed *F. sanguinea*, the hereditary disposition of the sensitive powers of cognition and appetite is so plastic, that with parties of almost equal numbers fear will be stronger in such cases than love of combat. First, of course, by tapping one another with their feelers they find out that they are strangers, and therefore they try to avoid each other; but if this is impossible, the perception of mutual similarity will gradually prevail over their mutual difference. In the beginning, they live together from necessity only, but they gradually acquire a *common nest-smell* which unites them as members of *one* colony. From this time, by taps of their feelers, they recognize one another as belonging to the same household. The former opponents have united into one "constitutional body" which is kept together by the common nest-smell. Strange though this mode of communication may appear to us who are not provided with antennae, it alone explains the fact otherwise wholly inexplicable, how the confederate colony thus formed will in future hold together even against former members of their own colony.[1] An example

[1]) On the explanation of the nest-smell see above p. 16 ff.

of this kind is related by Forel in his *"Fourmis de la Suisse."* One day he brought a handful of *F. pratensis* to a confederate colony of *sanguineas* and *pratensis;* the *pratensis* of this colony, two months before, had been taken from the same *pratensis* nest to which the new arrivals belonged.[1] What happened? Immediately the new *pratensis* were fiercely attacked by the *sanguineas,* because they were recognized as enemies by means of the "smell at contact."[2] The old *pratensis* seemed to recognize their sisters but faintly. They met them with suspicion and did not assist them, although on the other hand they did not take part in the fight. But soon they began to carry the new arrivals into the confederate nest, as if they belonged to it. The number of the *pratensis* was thus increased considerably, outnumbering even the *sanguineas.* Although the latter continued their hostilities against the newcomers for several days, and mutilated and killed several of them, it never occurred to the old *pratensis* to make common cause with their maltreated "sisters" against their natural enemies. They allowed the *sanguineas* to have their own way, until the survivors had gradually acquired the nest-smell of the confederacy. In the course of a week "peace" was restored, and the strangers were treated henceforth, also by the *sanguineas,* as inmates of the same colony.

If ants had the power of rational reflection, if they

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[1]) Both had been taken from the *pratensis* nest when fully developed and not as pupae. Otherwise this example would be out of place when speaking of "allied colonies."

[2]) By this term Forel expresses very well the peculiar sensation of ant feelers.

had any idea of consanguinity, then this behavior of the old *pratensis* of that confederate colony during the maltreating of their sisters would be altogether inexplicable. On the other hand, the instinctive nature of ant sensation will furnish a very satisfactory explanation of this phenomenon, which is in evident contradiction with animal intelligence. Yet, it should not be forgotten, that societies of apes and other higher animals have nothing to compare with the confederacies of ants. No one has as yet observed, that wars carried on between different hordes of apes ended with a peaceful alliance between the combatants. This clearly shows, how wrong it is to exalt the societies of higher animals above those of ants in the matter of psychic endowments.

Evolutionists, therefore, such as Darwin and Ziegler, are sadly mistaken when they point to the battles sometimes waged between hordes of apes, and adduce these as conclusive evidence, that the societies of higher animals are so closely allied to the "primitive" societies of man, that a little, unimportant "step" bridges the difference; for first they imagine a "primitive state" of human society, which is depicted, of course, as brutal and as devoid of reason as possible; then, to match the picture, they exalt the societies of higher animals to the greatest possible similarity with reasonable man, and finally, from this twofold hypothesis they draw the conclusion that human society has evidently developed from the animal societies. And this is called the "consistent, scientific application of the theory of evolution to man!" If ants were endowed with reason and risi-

bility, they would surely burst into a hearty laugh at these evolutionistic "steps"; for, as to the development of social instincts, ant colonies bear a far closer resemblance to the human societies than the hordes of apes; and yet even the intelligence of an ant would be sufficient to understand, that animal and human societies are as far apart as heaven and earth. The difference between ant states and human societies is readily acknowledged; but the difference between hordes of apes and the primitive states of man *cannot* be conceded, because, forsooth, it is against the theory of evolution!

CHAPTER III.

ARCHITECTURE IN THE ANIMAL KINGDOM.

1. *A General Survey of the Building Activity of Animals.*

THE houses of animals are exceedingly simple and destined for very prosaic purposes; they merely serve the wants of daily life, the preservation of the individual and of the species. To their owners they are necessary helps in the struggle for existence; they never aim at art for art's sake.[1] This clearly shows, that in the animal kingdom we can speak only metaphorically of architecture properly so called. There is mere mechanical skill, but not *art*; and if sometimes its productions bear a faint resemblance to works of human art, the aesthetic effect is never either intended or understood by the animal. Another essential point of difference between the artistic skill of animals and of man is in this, that with animals it is due to an *innate, hereditary* aptitude which has not first to be *acquired,* as is the case with man. At its birth the animal is endowed with all its artistic talents. It applies them without previous experience or instruction, as soon as demanded by its organic development and by external circumstances. The caterpillar of the emperor moth (*Saturnia*) begins to be an artist only, when the time has arrived to transform itself into a chrysalis, and to weave a bottle-shaped case wherein it is to undergo

[1]) The buildings of the Australian *Tectonarchinae* are no exception to this rule, if we divest descriptions of them of all poetical additions.

the change. The female of the leaf-rolling beetle (*Rhynchites betulae*) becomes an artist, only when, the time of depositing her eggs having arrived, she is forced to cut and to roll up a birch-leaf in the shape of a graceful funnel. The male of this beetle is no more endowed with this wonderful, technical skill, than the emperor moth in the state of imago is able to spin a cocoon; for the artistic talents of animals depend on their organico-psychic constitution. Their application affords no trace of reflecting reason or free choice, because their mode of action is predetermined to the most minute detail by the laws of vegetative and sensitive life. Again, animals by their very organic constitution possess all the tools necessary for exercising their natural talents. Bees have their honey-bags to gather in the pollen and daggers to ward off their enemies; silkworms have their spinning glands, beavers use their tails as trowels, and their sharp gnawing teeth serve them as axe and chisel in working the wood. There is no need therefore, to invent or manufacture implements. Moreover, directions for using their natural instruments are furnished to animals by the *innervation* of their bodily organs and by the corresponding constitution of their sensitive powers of cognition and appetite. Reason and free choice, therefore, are *utterly superfluous* in the exercise of these animal talents. Since by their organico-sensitive constitution animals are provided sufficiently with all the necessaries of life, they are denied the higher, *spiritual* faculties. Hence, they, who attribute reason to animals, show that they have but a superficial knowledge of animal life.

The buildings of animals either serve to shelter the individual, or else they are places for breeding and rearing the young. To the former class belong the tunnels excavated in the earth by the serpulas, the envelopes made of various substances by the moth-caterpillars and the larvae of the may-flies, as also the different casings constructed by the larvae of insects, particularly of many butterfly-caterpillars before their metamorphosis. To the latter class belong the regular *nest constructions* of animals. The most primitive specimens are found with the parasitic *Nemertine* worms.[1] In several orders of insects, especially among the *Hymenoptera*[2] and the beetles, we meet with instances of ingenious and manifold development of the same art. Here we find the most various forms of nests, and made of all kinds of material. Those elegant little domes of mortar, the wasps of the genus *Eumenes* have built for their offspring. Those breeding burrows, lined with red poppy blossoms, have been excavated by the so-called rose-bee (*Megachile*). Those graceful funnels and barrels of leaves have been rolled into shape for their young by weevils (*Rhynchites, Apoderus, Attelabus*). And that boat adorned with streamers has been spun by the great water-beetle (*Hydrophilus piceus*), as a receptacle for its eggs. Among fishes nest building is rare. We find examples of it, in the stickleback (*Gasterosteus aculeatus*), and in other fishes provided with spines. On the other hand, birds are unsurpassed in the art of nest building as regards variety, both of

[1]) See "Naturforscher," 1886, 19th year, No. 50, p. 494.

[2]) See especially J. H. Fabre, "Souvenirs Entomologiques," who has described these buildings with admirable skill.

form and of the material used by different species. With the mammals,[1] finally, nest constructions are, on the average, far less complicated and artistic than with birds and insects.

The buildings which serve to shelter and rear the young, may likewise be used as permanent lodgings for parents and offspring. This is the case with social insects and many mammals. Thus the nest develops into a *family dwelling.* Only in relatively rare instances, do animals employ their building skill in providing other necessaries of life. Many spiders spin their webs not only as a hiding-place for themselves or for breeding purposes, but they also, by means of their spinning glands, manufacture nets wherewith to catch their prey. In like manner the neuropterous larva, which goes by the name of ant-lion, uses its earth-funnel both as a dwelling place and as a trap for catching its prey, which consists chiefly of ants or other insects. Among *ants,* however, we find the most varied and manifold application of natural architectural skill.

2. *The Nests of Ants.*

In the first place, ants use their architectural talents for *building nests,* in the strict sense of the word. Everybody is more or less familiar with ant nests, but few are aware of the immense variety of forms implied in that apparently simple term. As there is scarcely any material unfit for an ant nest, so it may assume all possible shapes and be found in the most unlikely

[1]) We shall consider more in detail the buildings of the beavers in the subsequent pages.

localities. Here it is the size of a thimble, there, the pyramids of the ancient Egyptians are like mole-hills in comparison, if we take into consideration the relative size of the builders. Some are in the ground, in clefts of rocks, or concealed by stones, others are under the bark or in the wood of trees. Others again are in the hollow stalk of a plant, or in a gall-nut or in a deserted snail-shell. Now they hang high in the boughs of a tree, now in forests they rise as domes from the level of the ground. Such a nest may be dug, or spun; it may consist of masonry, or of cavities hollowed out of the earth or of the wood. Sometimes all these modes of operation enter into the same construction. In short, the variability as to form, style, or locality is *almost unlimited.* There is *one* characteristic, however, common to all ant nests, viz: *the absence of any uniform architectonic pattern; ant nests are irregular systems of chambers and galleries, giving shelter to the ants and their offspring, and communicating by different openings with the outside world.* This very irregularity of their buildings enables the ants to suitably adapt their nests to any locality and to employ any kind of material in their construction. The artificial and, as it were, mathematical regularity of the honey-combs of bees[1] is entirely

[1]) *N. Ludwig,* in an essay, *"Der Zellenbau der Honigbiene,"* (in "Natur und Offenbarung," 1896, 10th issue, p. 598 ff.), has offered a new explanation of the hexahedral form of the bee-cell and of the three congruent rhombs forming its pyramid-like base. In his opinion the peculiar form of the bee-cell is due only to the construction of the wax combs, each cell being built only in connection with other cells. For the bees are actuated by the impulse of combining round cell-walls bordering on one another, into one single wall and to reduce their thickness by gnawing off both sides as much as possible without peril to their necessary strength. Hence, the flat walls of the form described

wanting. This difference is very important for comparative psychology. As in the social life of ants the individual independence of the single workers attains a higher degree than amongst bees, so in their architecture the same phenomenon may be observed. Instead of constant uniformity we find great variety; instead of the monotonous "automatism" of innate instinct, we meet with a quasi-intelligent arbitrariness in the exercise of their sensitive cognition and appetite. Scarcely anywhere else is the wonderful plasticity of animal instinct manifested so clearly and convincingly as in the architecture of ants. This was the reason why ants seemed to furnish such numerous proofs of the "individual intelligence" of animals; and, in fact, *in the architecture of ants, if anywhere in the whole animal kingdom,* we find a striking resemblance to human intelligence.

In order to give a full psychological description of ant architecture, we shall *first,* compare the nests of different species, *secondly,* we shall consider the differences in the buildings of one and the same species; in the *third* place, we shall examine the methods by which ants of the same colony co-operate in building their nest, and *finally,* we shall investigate the various purposes to which ants apply their architectural talents. However, it would require a volume of considerable bulk to treat these points exhaustively. Therefore, we

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above. The consequently elongated, prismatic form of bee-cells would be merely the result of the *extreme uniformity in the working* of the bees engaged in building the combs. Single cells are built by the same bees always in a cylindrical form with hemispherical top and bottom. This form is to be regarded, according to Ludwig, as the proper, primitive type of bee-cells, which is found with bumble-bees and other allied Hymenoptera.

must confine our discussion to its narrowest possible limits, touching chiefly on such features as are of special interest for comparative psychology.

Great as is the variety of ant nests, still, every species has its peculiar architecture, differing more or less from that of any other species. Many ants, e. g., our small, blackish garden ants *(Lasius niger)* and the small, yellow meadow ants (*Lasius flavus*)[1] work almost exclusively *in earth.* Their nests are dug in the ground, but above the subterranean nest they raise smaller or larger domes of earth, the stalks and blades of grass, that grow on the spot, serving as natural pillars and beams. Other species, again, e. g., our well-known hill ants (*Formica rufa*)[2] build so-called "ant-hills," the popular type of ant nests in our northern hemisphere. These ant hills may be termed *mixed buildings,* an under-ground earth nest being combined above ground with a dome consisting of earth, pine-needles, scraps of dry leaves and stalks, and other parts of plants. The different ant species which build such ant hills follow systems and styles peculiar to each. Thus any one with a little practice is able to determine at once the species of the builders. *F. rufa* builds differently from *pratensis, pratensis* from *exsecta, exsecta* from *sanguinea.* The universal tool which, like the human hand, is fit for and skilled in a

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[1]) Both are found also in N. America; the most common yellow ant there is *L. aphidicola Walsh; L. niger* is represented by its very common N. American race *L. americanus Em.*

[2]) The N. American species of the *rufa* group are very numerous; among them the nests of *F. exsectoides For.* and *obscuripes For.* are most like the European ant hills of *F. rufa.*—An interesting description of N. American nests is contained in a paper of Father H. Muckermann, S. J., entitled "The structure of the nests of some North American species of Formica." ("Psyche," June, 1902.)

variety of performances is found in the *jaws* (mandibles) of the ants. Of course, in digging burrows in the earth and in constructing earth-works they are also assisted by their fore-legs, which help partly to scrape up the sand and partly to hold down and fasten pellets of earth. In closely allied species the shape of these instruments, and especially that of the all-important toothed inner edge (cutting edge) of the mandible, is as a rule so similar[1] that the specific differences in architectural style can be accounted for only by the

Fig. 2.
Left mandible of *Formica rufa.* (Worker.)

Fig. 3.
Right mandible of *F. sanguinea.* (Worker.)

instinctive preferment of a particular style on the part of different ant species. In the case of ants, therefore, it will never do to resort to the mechanical automatism of animal activities, and to explain the differences of instincts merely by differences of bodily organs. The decisive factor is *the psychic variety of instinctive dispositions.* By them the bodily organs, in themselves indifferent, are directed in their various modes of operation.

It is true, to a certain extent, that the nature of

[1]) See the subjoined cuts. Both are drawn with the Zeiss' microscope, syst. A_1, and Abbe's *Camera lucida.*

the exterior organs of ants will also decide the nature of their architecture. Thus e. g., the large *Camponotus ligniperdus* (horse ants) and their allied species possess larger workers, whose huge head and strong mandibles enable them to cut galleries in the wood of decayed or even of sound trees. And therefore these species are remarkable for *wood nests*. Others again, among them the jet black *Lasius fuliginosus* as the only one of this kind among the emmets of northern Europe, build *paper nests* by gnawing wood-fibre and gluing it together with the sticky product of their salivary glands. They thus produce a coarse, brown papiermaché, in which they establish their nests. Far more perfect are the paper nests made by several foreign ants, especially in South America, Madagascar and East India. They resemble irregular, brown or grey-colored wasp-nests, suspended from or fastened between branches of trees. Rev. A. Schupp, S. J., sent me from Porto Alegre (South Brazil) several paper nests of *Cremastogaster sulcata*, one of which on arriving in Holland still contained several thousands of live inhabitants. Similar nests of *Cremastogaster Schenki* in Madagascar are reported by Sikora to be sometimes of such size as to accommodate a full-grown man. From these paper-nests we must distinguish nests which are spun and do not consist of a paper-like material but of a texture like cobwebs. Such webs are constructed, according to Wroughton's observations,[1] by an East Indian ant *Polyrhachis spinigera* for lining her earth-burrows. Other Indian and Australian ants of the genera *Oecophylla* and *Poly-*

[1] "Our Ants," part I, p. 25 ("Journal of the Bombay Nat. Hist. Soc.," 1892).

rhachis build their nests on trees by sewing together clusters of leaves. It is now finally ascertained (see p. 128-129), whence the Oecophylla procure the material for their threads. They do not secrete it from their mandibular glands, as was hitherto supposed,[1] but they use their young larvae as *"spinning-wheels,"* moving them to and fro between the edges of the leaves. This strange fact observed already by Ridley and Holland[2] has recently been confirmed by other scientists.

Another class of ant nests, likewise found in the tropics exclusively, are the natural cavities in the stems, thorns and bladder-shaped swellings of the so-called "ant-lodging plants," which invite ants to take possession of their well furnished lodgings. Several of these plants, as the American Imbauba *(Cecropia adenopus)* offer to the ants, besides the lodging, also an agreeable food in the form of special honey-bearing nectaries. In return for their kindness the "ant-lodging plants" are afforded by their valiant lodgers effective protection against leaf-cutting ants and other herbivorous insects.[3] This mutual relationship of the ants with the plants in question is called *Symbiosis* (consociation). It bears, in fact, some similarity to the associations existing between animals of different

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[1]) *E. H. Aitken*, "Red Ants Nests" ("Journal of the Bombay Nat. Hist. Soc.," 1890, Vol. V, n. 4, p. 422), also *Forel*, "Die Nester der Ameisen" (Zuerich, 1892), p. 19.

[2]) *E. E. Green*, "On the Habits of Oecophylla smaragdina F." ("Proceedings Entomol. Soc. of London," 1896, p. IX.)

[3]) *Fritz Mueller*, "Die Imbauba und ihre Beschuetzer" ("Kosmos," VIII, 109), and *A. F. W. Schimper*, "Die Wechselbeziehungen zwischen Pflanzen und Ameisen im tropischen Amerika" (Jena, 1888). Also *H. v. Jhering*, "Die Ameisen von Rio Grande, do Sul," in "Berl. Entom. Zeitschr.," 1894, 3d issue, p. 354 and 364 ff.

species, e. g., between ants and their guests, such as the club-bearing beetles *(Claviger)*, the tufted beetles (*Lomechusa, Atemeles*), etc. But even those cavities of plants, which are properly not meant to receive and to lodge ants, are often occupied by them, especially in the luxuriant vegetation of tropical South America. Aug. Forel in the winter of 1895 and 1896 visited the savannas of Columbia, where he found that the nests of by far the most of the species, belonging to eight different genera, were built in dry stalks of grass.[1] This led him to think that in the prairies and forests of tropical America the *nests in stalks* and in hollow parts of plants were the typical form of ant nests, corresponding to the climate of that country, whereas in our zones the usual type is the earth nest or else the hill made of earth and parts of plants.

This cursory comparison of the various forms[2] of nests met with in different ant species, shows clearly enough, that their character is conditioned by the peculiar shape of the bodily organs of the builders, but far less than is the case with most of the other artistic instincts in insects and other animals. The form of the mandibles, the presence of salivary glands with gluey secretions or of real spinning glands, indicate only the general outline of the architectural style preferred by their owners. Only the different instinctive dispositions of the builders determine more exactly the specific differences of their nest forms.

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[1]) "Quelques particularités de l'habitat des fourmis de l'Amérique tropicale" (Extr. des Ann. de la Soc. Entom. Belg., XL [1896], 167 ss.) and "Zur Fauna und Lebensweise der Ameisen im columbischen Urwald," in "Mitteil. der Schweiz. Entomol. Gesellsch.," IX, 9th issue,

[2]) *Forel*, "Die Nester der Ameisen," Zuerich, 1892.

Within the limits of these instinctive, hereditary dispositions there is plenty of room for the worker ants to give full play to their individual powers of sensitive cognition and appetite. This is why certain ant species, particularly those skilled in earth work or wood work, often take possession of some spot so suitable for their dwelling as to be practically half-finished. This they fit up in a becoming manner as a home for their colony. Such attractive spots are e. g. on the heaths of northern Europe rotten tree-stumps, in which for years numbers of bark-beetles and their larvae or other wood-boring insects were kind enough to prepare comfortable quarters by carving out an extensive system of galleries and chambers. It only remains for the ants to take possession of the lodgings, devour the former inhabitants, if there be any left, clean the apartments, close up the superfluous entrances with earth or rotten wood, and with the same materials construct, if need be, a few partitions for separate chambers. If, on occupying the residence, they should perchance discover that part of the stump is already inhabited by another ant colony, the latter are killed or turned out without much ado. If they should fail in this, they make peace and live on good terms with the rivals, especially if the latter are equal to them in fighting strength, but differ greatly in size and means of defense. The nests are separated by partitions, and the stump is henceforth inhabited by a "compound nest."

Such "stolen nests" form a large category of ant nests, particularly in places where there are many stones; for almost all ant species that dwell in earth

nests, have a predilection for building under stones. This saves them a great deal of work and gives the whole building greater firmness, and, moreover, in such a nest the heat of the sun more easily penetrates to the interior. In heaths also, where stones are rather rare, instances of such stolen nests may occur. A nest of *F. sanguinea*,[1] on which in 1894 I had placed a clod of heath serving it henceforth as roof, had in 1895 passed into the possession of a colony of *Lasius niger;* in the years 1896-98, it was again inhabited by *F. sanguinea.* A short time ago, in the *same* region near Exaten, I found a rather extensive earth hill supported in the centre by a bunch of heather and inhabited by a large colony of *F. rufibarbis.* The ants had collected on the surface a small heap of dry heather-leaves, as they generally do there. The earth hill itself, however, judging by its architecture, was an old nest of *L. niger,* which subsequently had been occupied by the *rufibarbis.* History is silent as to whether the original builders of the nest had quitted it before the time of the foreign invasion, or whether they were compelled by force to evacuate it.

F. sanguinea are a restless people. They frequently desert their nests, which are then taken possession of by other, smaller species (especially *Tetramorium caespitum, L. niger* and *alienus*). I have noted a number of such instances in my records of the last few years; it may suffice to mention one of the most remarkable. A large colony of *F. sanguinea* (No. 72 of my stat. map), in 1895 and 1896, had inhabited a group of three nests, distant from one another 3 and

[1]) Colony No. 155 of the statistical map.

7m. respectively. Since the spring of 1897, however, they had emigrated and I did not find them again. In 1898 the northernmost of these nests was empty, the central one was occupied by *L. niger,* and the southernmost by *Tetramorium caespitum.* This was the state of affairs until July, 1898. When I returned on July 14, I found that the *sanguineas* of colony No. 72, which I could easily recognize by the size of their workers, had returned to the southern nest which consisted of two little heaps in close proximity. From one of these the *Tetramorium* had already been completely driven out; in the other they still occupied a retired corner and were surrounded by the *sanguinea* nest. Therefore ant nests also have their fates.

Ant nests are stolen not only by ants of different species, but sometimes by those of different colonies belonging to the same species. Many instances of this kind are furnished by the *sanguinea* colonies in the neighborhood of Exaten; but for brevity's sake, it must suffice merely to mention the fact.

3. *The Nests of the Sanguine Slavemakers.*

The great plasticity and power of adaptation to given circumstances in the nest-building instincts of ants is seen to the greatest advantage by an examination of the nests of the sanguine slavemakers (*F. sanguinea*). With members of one and the same species possessing the same specific, natural constitution, there is such a variety of nest construction, that there is no trace of that "automatism" of instinct, which postulates a completely uniform and monotonous manifes-

tation of the hereditary instinctive activities. As these ants, in the parlance of modern animal psychology, possess a high degree of "individual intelligence," because under the influence of their sense-perceptions and sense-experiences they are able to adapt their innate, instinctive dispositions and aptitudes to any kind of circumstances, so they manifest great adaptibility in the building of their nests. I have drawn up statistics of the *sanguinea* colonies in the neighborhood of Exaten, which show that to my knowledge there are in this region about 2,000 nests of this ant species, embracing 410 colonies. The architectural style of the nests varies greatly. By far the majority of them are underground, built either below the bare surface or under a shrub of heather, beneath a loose clod, under a stone or at the foot of a tree. In connection with this underground earth-nest there is generally on the surface a greater or smaller heap of dry leaves collected from the heather shrubs. This heap, together with the earth carried out of the interior galleries and the twigs of the shrubs supporting the whole construction, forms a sort of protective dome. With large nests this hill sometimes has a circumference of several meters and a height of several decimeters (e. g., in colonies Nos. 208, 216, 118); but often it is rather insignificant and sometimes it is altogether wanting. Besides these simple or mixed earth-nests, *F. sanguinea* builds also in rotten stumps of fir-trees or oaks, now under the loose bark, now in the wood, now in the roots. Sometimes the old stump is surrounded by earth-galleries, and sometimes the whole nest is confined to the stump itself. The nest of one of our

sanguinea colonies here (No. 112 of stat. map) is built in a lofty and sturdy oak, in the mould and the clefts of a hollow in the tree, almost a yard above the ground. These observations show that the sanguine ants are able to choose the most peculiar places for their nest and to adapt its construction to any local circumstances. This is confirmed by the following observation. In the immediate neighborhood of Exaten the earth-nests prevail, while two kilometers further or near the village of Grathem, the greater number of nests are built in rotten fir-stumps, because in that region the ground is more turfy and thus renders the construction of earth-works rather laborious.

Not less variable than the *style* is the *number* of nests constituting a colony of *F. sanguinea.* Among the above mentioned 410 colonies which are known to me in this region, there are but a few that have only *one* nest. These are mostly weak tribes which, on account of the scarcity of members, feel no need of other nests. In some cases, however, even a very strong colony has only a single nest built in a specially convenient place, generally at the foot of a fir (e. g., col. 208 and 216). In such cases the concentration of the building is of greater advantage than its division into a number of different nests. However, by far the majority of the *sanguinea* colonies have several nests, averaging from two to eight, either close together or farther off from another, sometimes inhabited simultaneously, sometimes by turns. The distance between the nests of one colony is mostly only from ½ to 4 m., but sometimes from 10 to 20 m. or more. The latter is particularly the case with their

summer and winter residences, or rather with the *abodes for winter and for spring*; for, many but by no means all *sanguinea* colonies of this country have special winter-quarters established in thickets under the roots of trees or stumps and affording deep and warm recesses for the cold season. The spring residence, however, which again often consists of several single nests, is generally built near the edge of the thicket. Here, on the first warm days of March and April, the ants can always be observed changing their quarters and moving over with the whole family to the spring residence. In September or at least in the beginning of October they change again, moving in the opposite direction.

If it should become very hot and dry in summer, the colonies move to their winter quarters during the dog-days, thus converting the winter nest into a mid-summer nest.[1] When at the end of August, 1898, I had returned after several weeks of absence, I found that during the exceptionally hot days of August most of the *sanguinea* colonies of this region had abandoned their spring nest. What had become of them? As I was well acquainted with the winter nests of many colonies by the means of the statistical map I had drawn up in the preceding years, it occurred to me to look there in search of them. The result was rather striking: all of the emigrated colonies possessing winter quarters of their own, had already occupied them! This was such a regular occurrence, that, when

[1]) The country about Exaten consists in its uppermost layer of light sand, which at once loses all its moisture in places exposed for some time to the scorching rays of the sun. This condition of the soil is surely essential in explaining the facts just mentioned.

I found the spring nest deserted, I had only to look where a given colony had passed the winter; there they would be found under the clods of their nest. Strange, you might say, to use one's winter quarters as a summer resort! Yet, on considering the shelter afforded by a winter nest, situated in the brushwood or at the roots of a shady tree, we may easily understand that the *very same* place can protect ants both against the cold of winter and against the scorching heat of summer. In this winter and midsummer nest the *sanguineas* generally stay during autumn and prepare for their hibernation. Whilst the hill ants (*F. rufa* and *pratensis*) are still busy building their hills and setting out on expeditions to visit aphides, whilst the small, black lawn ants (*Tetramorium caespitum*), the red stinging ants (*Myrmica rubra*) and the small, brown garden ants (*Lasius niger*) are still in full activity around their nests and are accompanying their winged sexes on the way to their nuptial flight, there prevails in the nests of *sanguinea* a quiet in striking contrast with the feverish activity of the inhabitants during the former months. The really active season for *F. sanguinea* is from the middle of March to the middle of August. Therefore their spring nests also may be called *working nests,* whereas their winter nests, which serve for midsummer and autumn, may be called *nests of repose.*

Besides these *periodical* changes of residence, *F. sanguinea* will also *incidentally* move to another nest within the temperate or hot season. This moving is caused by special conditions of the weather. If, on account of long aridity and heat, the *sanguine* ants begin

to feel uncomfortable in their residence on the southern edge of a fir-plantation, they emigrate, bag and baggage, to the more shady side on the north. Toward the end of May, 1896, I observed several colonies changing their nests for this reason. If the weather changes and continues to be chilly and rainy, they bundle up once more and go back to the old home. A similar instance, I noticed on June 20, 1896. There had been heavy showers for several days back and many *sanguinea* colonies that hitherto had lived in earth-nests were moving into old oak stumps; for these afforded them a better shelter against the penetrating rains. Those who designate as *"intelligence,"* every suitable change in instinctive activities, caused by sense perceptions and sense experiences in animals, can hardly escape from crediting ants with rather a considerable degree of animal intelligence; for even in the highest mammals we hardly find a higher degree of *"psychic plasticity,"* than is manifested in the above examples by the sanguine slavemakers. However, we have already shown in a former essay (Instinct and Intelligence in the Animal Kingdom), that it is entirely wrong to apply the term "intelligence" in this manner; for the phenomena in question can be fully accounted for by instinctive sensation and, therefore, they do not supply the least evidence in favor of intelligent, mental activity of the animal. Man, of course, in observing such phenomena, can attribute to the ants the following reasoning: "For the last few days it has been raining a great deal. We and our children have become dripping wet. Now, we do not want to get wet again; therefore, we must move to another dwell-

ing, where the rain can not enter; those old oak stumps, however, are just the thing; *therefore* we move to that place."—We, however, maintain: *Without* admitting animal intelligence the whole affair is explained much better from the instinctive association of sense representations. The ants do not like the old place any more on account of the disagreeable experiences undergone there, therefore they look for another. That under these circumstances, just those dry oak-stumps appear to them to be so very inviting, follows from the suitable disposition of the sensitive cognition and appetite. That ants in such cases are *intellectually conscious of the suitableness of this change of nests,* is an unwarranted assumption to which we reply: *quod gratis asseritur, gratis negatur.* In other words: we are not allowed arbitrarily to attribute a human course of reasoning to animals in the sense of "popular" psychology. Such men as L. Buechner may find a proof of the "high intelligence" of ants in the fact that, e. g., in low-lands *Leptothorax acervorum* resides under barks of trees, but in the Alps under stones.[1] Although we consider the power of adaptation manifested by the *sanguineas* in their nest-building instincts far more deserving of admiration, yet we are far from regarding even this power as an instance of animal intelligence, but, rather, of animal instinct, the various activities of which depend neither

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[1]) *Buechner,* "Geistesleben der Thiere," p. 73. In this book the author calls *Leptothorax acervorum* erroneously *Lasius acervorum. Romanes* in his book, "Die Geistige Entwicklung im Thierreich" (Leipzig, 1885), p. 268, was surely referring to the same passage of Buechner, because he still more erroneously calls that ant *Lasius acerborum.*

on mechanical automatism nor on individual reflection of the animal, but on the suitable disposition of its sensitive cognition and appetite.

True, the plasticity of the building instinct is greater with the *sanguineas* than with their allied species; yet even the latter sometimes perform actions that go to prove clearly, that the nest-building instinct in ants is not blind mechanism, but is suitably modified by their sensitive cognition. I observed a striking instance of this kind in the summer of 1808 at Lippspringe in Westphalia. In a growth of young fir-trees near the so-called Fisherman's hut there lay a small heap of old pieces of tar-paper. This treasure had been discovered by some *Formica truncicola Nyl.*, which had their nest at a distance of 64 m. in a fir-plantation on the other side of a broad, sandy road. Their nest was a normal *truncicola* nest, a hill of fir-needles and earth, built around a fir sapling. Now, the ants were better pleased with the newly discovered place under the tar-paper, than with their original nest, therefore they moved over, bag and baggage; and the moving lasted several weeks. The tar-paper afforded them in a far higher degree the advantages usually derived from their surface domes called ant-hills, for under the layer of tar-paper warmed by the rays of the sun there was a uniformly higher temperature and, at the same time, an effectual shelter against the rain. Therefore they established their nest under the tar-paper *without* surmounting it by a hill. When I returned to Lippspringe at the end of May, 1809, the *truncicola* nest was still under the tar-paper, no indications of any building being visible above ground. Their former

hill in the forest, however, was in ruins, a sign that it had been completely abandoned by its builders.

Neither experience, nor instruction, nor "profound thought" could have taught the ants, that tar-paper possesses in a high degree the qualities which allowed them to dispense with an ant-hill; for it was a material which ants are not wont to meet with. It is not, therefore, "intelligence," but the instinct of ants that rightly accounts for a change of nests seemingly so wise. The first ants that happened to find the paper were delighted with the place; their senses were impressed with its comfort and security. This led them to bring over some of their nest-mates, and since these also were pleased, the whole colony finally emigrated and settled at the new place. The sensitive powers of cognition and appetite also explain very easily, why the ants did not raise a hill above the tar-paper. Under the artificial roof they felt safe and warm enough without a superstructure, therefore they saw no need of any additional construction. Other ants, too, often omit to build above ground, when they meet a stone, that furnishes sufficient warmth and protection for the underground parts of the nest. Even of *F. rufa,* which is the most typical "hill-ant," I found a series of nests under stones, *near Goebelsmuehl,* (Luxemburg) in July, 1904.

As ants, and in particular the sanguine slave-makers, are able to adapt their skill in building nests to the most varied localities and conditions of season, so the same instinct manifests great plasticity with regard to sudden emergencies, e. g., against the attacks of their various enemies. A weak colony of *F. san-*

guinea selects for its nest a more hidden place than a stronger one does. This is especially the case, if there are hostile ant species in the neighborhood, liable to pay them a visit at any time. Thus colony 166 of my statistical map of Exaten, being harassed by neighboring *pratensis,* had at last hidden itself so well in the earth, that I was obliged to spend a considerable time before finding it. I myself have often enough been vexed to see that colonies of the same *sanguinea,* on being disturbed even by the hand of man, emigrate and seek elsewhere a new place of settlement. Sometimes even a clod of heather placed on their nests will cause weaker colonies to emigrate. This is all the more strange, since our *sanguinea* is very fond of using such clods as a roofing for her nests. Other colonies, indeed, did not emigrate on account of my repeated visits, but tried to retire farther into the interior. A striking instance of this kind was offered by colony No. 36, which was of moderate dimensions. Originally the exterior of the nest looked like any common earth-nest of the same numerical strength. The clod which I had placed on it was used as a roof and was covered by a heap of dry heather leaves. I often visited the nest and each time I lifted the clod to have a view of the interior of the building. In consequence the ants blocked up the former entrances; they dug new ones at a greater distance from the nest, and came to the surface much more rarely. Even the small heap of materials gathered from plants gradually disappeared from the top of their nest. After a time it was blown or washed away, nor did the ants renew it. It was evidently instinct that led

them to withdraw from these repeated disturbances by closing up and concealing their nest.

Professor Aug. Forel[1] relates that he had brought home from Algeria a colony of *Myrmecocystus altisquamis* and placed it in his garden at Zuerich; but owing to the trouble caused them by the small ants *Lasius niger* and *Tetramorium caespitum* they gradually modified their usual manner of nest construction. Under normal circumstances this *Myrmecocystus* species has wide open nest entrances; in this case, however, they were contracted to afford greater protection against the thievish visitors, and finally they were almost entirely closed up. This instance is similar to the one recorded above of colony 36 of *F. sanguinea,* and is psychologically to be explained in the same way. The repeated disagreeable experiences caused to the ants by the troublesome strangers induced the *Myrmecocysti,* contrary to their former habits, to close up and to conceal their nest. As Forel points out, these facts afford irrefutable evidence of the great plasticity of ant instinct. For, this instinct is not merely a nervous mechanism forced to operate along uniform lines; it includes sensitive cognition and appetite, which are not only of an organic but also of a psychic nature. Thus animals are enabled, by new sense perceptions and experiences, to adapt their wonted mode of action to the requirements of circumstances. This does not, however, compel us in the least to attribute to animals a power of cognition essentially the same as human intelligence;

1) "Les Formicides de la Province d'Oran" (Lausanne, 1894), p. 8; see also "Aperçu de Psychologie comparée," p. 24, by the same author.

a fact we cannot even do so, if we wish at all to proceed scientifically. Popular psychology may, indeed, perceive a "spiritual power of reflection" in those activities of animals, in which sense experiences enter as additional factors, and of course, this mental procedure forces them, in consequence, to ascribe to ants at least the same degree of "individual intelligence" as to the highest mammals, for, with the latter great plasticity of instinct is rarer than with ants. These conclusions, which are declared absurd by modern evolutionists themselves, clearly prove the untenability and self-contradiction of modern animal psychology.

4. *How do Ants Build Their Nests?*

In spite of its irregularity every ant nest is always a unit, consisting of one or more chambers, galleries and entrances, by which ants communicate with the outside world. And now we are confronted with the question: How do the members of a colony co-operate in building their nest?

Almost a hundred years ago Peter Huber[1] accurately observed the ants building their nests, and described in a masterly manner the skill and assiduity of these small animals. Any one can satisfy himself of the correctness of these observations by watching wood ants [*Formica rufa*] building their hills on some sunny day in spring, or by looking at the small black garden ants [*Lasius niger*] constructing their earthen nests during some warm spring shower.

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[1] "Recherches sur les mœurs des fourmis indigènes" 1810. Nouvelle édition. 1861. Chap. I.

In building nests the single workers co-operate differently in different species; nowhere, however, do they co-operate with the regularity of a machine or according to a rigid pattern, but each ant with evident liberty follows her own impulse and her own plan. It is above all the instinct of imitation, which nevertheless causes a uniform result, a nest consisting of communicating galleries and chambers. As a rule the most zealous and skillful worker is imitated most; her zeal is catching, so that she directs the activity of the others into the same channel. This mode of co-operation effected by means of the instinct of imitation is predominant in hill ants (*F. rufa*) and the small, blackish garden ants (*Lasius niger*). *F. fusca,* however, the greyish-black slave ant or negro ant, (Huber's *fourmi noir-cendrée*) belongs to those species, in which the independence of the several workers in building is especially remarkable. The same is observed with the closely allied *F. rufibarbis* (Huber's *fourmi mineuse*). I often witnessed in these two species, how the pellets of earth, which one worker had just put down for building a wall in a certain place, were carried away by another one in order to apply them elsewhere in a manner more suitable to her own taste. To observers, who know the habits and doings of ants but superficially, and are wont to transfer their own thoughts into the brain of the animal, such occurrences may appear as though an ant wished "purposely to correct" the work of others. And, as a matter of fact, one of P. Huber's observations[1] bearing on this head has been actually

[1]) L. c., p. 43.

thus interpreted by writers on popular science, and made to serve as a beautiful proof of animal intelligence. This kind of arbitrary misrepresentation of the plainest facts can certainly lay no claim to any scientific value.

How, then, do ants build their nests? They adapt themselves to given situations and prudently take into account the various circumstances. When in spring a gentle, warm rain begins to render the dry soil soft and manageable, immediately the earth-working ant species are kindled with new zeal for building. These assiduous little animals will then sally forth from their nests by hundreds and place pellets of earth upon pellets to build new galleries and chambers, availing themselves of blades of grass, twigs of heather, pieces of leaves and other natural props as pillars or vaults. For the same purpose such auxiliary materials are also first dragged to the spot. In this connection the sanguine slavemakers give evidence of eminent skill in combining timber-work with masonry.

It is especially remarkable with earth-working ants, that they accommodate their instincts to the changes of temperature and moisture. This could be ascertained constantly in glass nests, in which I kept under observation small colonies of *Lasius niger, Tetramorium caespitum* and *Myrmica scabrinodis.* If the moisture of the nest became too great, the ants would set to work and pile up the earth in the shape of a dome perforated by innumerable openings, making it appear like a sponge; thus the evaporation of the water was facilitated. But when the moisture decreased too

much and the nest threatened to dry up, a change to the opposite was effected; the nest was constructed as flat and as low as possible with very few openings on the surface. The propriety of such proceedings is certainly striking. Often enough the same can be observed also in nature, both in those species that build only domes of earth, and in those that build regular ant-hills. It is a fact even noticed by farmers and ascertained by myself repeatedly, that in dry and hot summers the hills of wood ants are lower and flatter than in moist and cold summers. The first way of building is for the purpose of reducing evaporation to the lowest limit and to offer to the hot rays of the sun but a small surface to shine upon; on the other hand, the higher and the more vaulted the hills are, the easier is the drainage in case of rains, and the greater are the evaporating and heating surfaces. Indeed, ants would have to be *very intelligent,* if their own reflection should lead them to modify their nests so prudently. Yet, considering that the *dome shape* for the nest includes in principle these quasi-intelligent adjustments to the variations of temperature and moisture, which can be *traced,* in consequence, to the *specific* manner of building proper to the ants in question, it is clear that *instinct* and not *intelligence* is the guiding principle; for, the specific plan of the building is, no doubt, *instinctive,* as is acknowledged at least by scientific authors. In adjusting, however, their instincts to changing circumstances, the animals are influenced by sensitive perceptions and experiences, which are nothing else than the *natural exercise of the same instinctive power of cognition,* on which is

based the specific mode of building in any species of ants. Why, therefore, introduce a foreign element, called intelligence, between this hereditary disposition and its changeable application? I should think it is far more simple and natural *to account for the whole activity of an animal by one and the same principle.* Unless you mistake instinct for mechanical automatism, it is by no means necessary to assume animal intelligence in order to explain the above phenomena.

Let us now compare the architecture of ants with that of birds. There are several important differences. The nests of birds are more artistic[1] and regular; yet they are stamped with the unmistakable marks of monotony and uniformity within the same species, they are products of instinct in the strictest sense of the term. Moreover, as Altum[2] has admirably proved, the architecture of birds is a function of their breeding instinct. It begins at a certain stage of the development of this instinct; both reach their climax at the same time, and then gradually vanish together. On this account the nests for the first hatching in spring are, as a rule, built better than those later in the season. In this case practice does not form the master but the bungler.[3] With ants, however, architectural skill is found in the workers throughout their life, it is suitably carried into

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[1]) By the way, this art has often been exaggerated. See "Die Baukunst der Voegel auf ihren wahren Wert zurueckgefuehrt," in "Jahrbuch der Naturwissensch." I (1885-1886), 198.

[2]) "Der Vogel und sein Leben" (6th ed.), p. 163 ff.

[3]) Something similar obtains also among the Coleoptera in the ingenious nest-building of the leaf-rolling beetle (*Rhynchites betulae*). See *Wasmann,* "Der Trichterwickler, p. 78 ff.

operation under the most different circumstances, and is even to a certain degree improved by sensitive experience, i. e., it is modified according to new perceptions. True, many birds, too, are able to adapt to changing circumstances[1] the places and the materials they choose for their nests; nor can their instinct be called mechanical automatism, because its activities are governed by the sensitive cognition of the animal. Many species of birds change the place and the material of their nests according to locality; besides, the single individuals are not rigidly bound to a certain material for building their nests, but they frequently employ scraps of paper, horse hair, cotton and other materials, which happen to come in their way. Those birds that build nests more or less open to view, instinctively avoid materials the coloring of which would set their nest into striking contrast with the surroundings. In this they are evidently governed by their power of sense-perception. Sometimes this protective resemblance of the nest with its background is effected quite of itself, when birds use the material for their nests, which is usual and natural to them; but sometimes also unusual materials found by chance serve the same purpose. Thus I was informed by a friend:[2] "In Blyenbeck (in the northern part of Dutch Limburg) I had occasion to observe how chaffinches in building their nest 'ingeniously' imitated the greyish-white color of lichen which covered the tree on which they built. They used small scraps of paper, and thus

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[1]) Several examples of the same are found in "Westfalens Thierleben," Vol. II. Besides also in Darwin's posthumous essay on instinct (*Romanes*, "Evolution in the Animal Kingdom," appendix).

[2]) Rev. L. Dressel, S. J.

they disguised their nest."[1] The visual resemblance between the white tree-lichens and the paper-scraps, which impressed the sensitive power of perception of those chaffinches explains quite naturally their seemingly intelligent proceeding.

He, who concurs with Darwin[2] in attributing intelligence to birds when their actions are influenced by sensitive cognition, must credit ants with a still higher degree of intelligence; for it cannot be denied that birds, in building their nests, show far more specific uniformity than individual variability, whereas in ants, as a rule, the contrary is the case; with them the "*psychic plasticity*" of the nest-building instinct is no doubt much greater.

Yet the chief point of excellence, which distinguishes the architecture of ants from that of birds is the *number of uses* to which it may be put. Birds build *nests* to serve as places for hatching their young only; except during the pairing season, birds do not know their nests, nor does it ever occur to them to use them as dwelling-places. With ants, however, nests serve as permanent abodes for the whole family and often also for strangers of different species, which are hospitably received as guests. Finally, ants use their architectural skill for many other purposes. But before entering into particulars on this head, we would like to draw a comparison between the architecture of *mammals* and that of ants.

In as far as the buildings of many mammals are

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[1]) Ch. Darwin, too, mentions already a nest of a chaffinch described by Hewitson, in which, instead of lichens, shreds of paper likewise had been employed (l. c., p. 417).

[2]) L. c., p. 414.

not only nests but also permanent dwellings both for the parents and the young, they bear a closer resemblance to the nests of ants than to those of birds. Instances are plentiful; for the burrows of badgers, foxes and wild rabbits are well known. In some cases the same buildings serve also for storing provisions, as is the case with German marmots and moles. These buildings, therefore, by their greater universality of purpose, are more similar to ant-nests than to bird-nests. Another point of similarity with the former is in this, that they show, with some species at least, a greater individual variability and less specific uniformity than the latter. Nevertheless, in all these respects ant-nests by far excel the buildings of mammals. The very highest vertebrates, the anthropoid apes, scarcely manifest a trace of building instinct or of its intelligent application, unless you wish to mention the sleeping-places somewhat resembling regular nests, which Orang-Utans[1] are wont to build on trees. Although the brain of apes most resembles that of man, yet the most "intelligent" architects among mammals are found, not among the apes but among the rodents, which in development of brain are far inferior. *Beavers* are the only higher animals whose architecture can bear comparison with that of ants.

The buildings of beaver-families consist of an underground chamber and burrow resembling those of other mammals, and of a so-called "lodge." The manner in which the latter is built was ably described

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[1]) See *Buettikofer,* "Zoologische Skizzen aus der Niederlaendischen Expedition nach Central-Borneo" (Compte rendu du 3me Congrès international de Zool.), p. 224.

by Friedrich in a recent publication.[1] The beaver-lodge is nothing but an accumulation of brushwood above the opening of the underground chamber, which is the real center of the whole dwelling. Wherever beavers are living in colonies and when circumstances favor the full development of their instinctive skill in building, they construct their well-known dikes[2] to dam the water, and sometimes they even build canals for the transportation of timber. Although these works are the result of the co-operation of several families, yet each pair works only for its own purposes; there is never any division of labor like that in ant colonies. Of course, observers like Lewis H. Morgan,[3] who mistake for intelligence every action due to sensitive cognition, discover many proofs of high intelligence in the doings of the American beavers. However, this so-called "free intelligence" is nothing else than the power of adapting their buildings to the changes of situation. This power is possessed also by ants in at least an equal degree. If Morgan and Romanes,[4] e. g., regard it as an infallible proof of the intelligence of beavers that they regulate the level of their ponds by widening or narrowing "the orifices of their dams as the case may be," they should admit the same in ants, which regulate the degrees of moisture and temperature of their nests by changing

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[1]) "Die Biber an der mittlern Elbe" (Dessau, 1894), p. 20 ff.

[2]) According to Friedrich they also occur at some places on the banks of the middle Elbe, although indeed on a smaller scale; therefore they are due to an instinct common both to the European and the American beaver.

[3]) "The American Beaver and his Works" (Lippincott & Co., 1868).

[4]) "Animal Intelligence" (6th ed), p. 377 ff.

their domes accordingly; and, just as beavers use their architectural skill not only in building nests but also in constructing dams and canals, so ants use theirs for far more various purposes. Those who concur with Romanes in maintaining that "the adaptations of pure instinct have reference only to conditions that are unchanging"[1], and that meeting of continual *variation* of conditions cannot be accounted for but by *intelligence,* must, indeed, attribute to beavers a considerable degree of individual intelligence, but no less to ants. However, this conception of instinct and intelligence is untenable. Even Romanes is loath to ascribe to beavers such high psychic faculties, yet with his false notion of intelligence this conclusion is unavoidable. If beavers in modifying their buildings are guided by *their own reasoning,* they must be likewise credited with an *intelligent knowledge* of the principles of their architecture; for the former without the latter is impossible; thus, we have, instead of their building instinct, the highest order of human, architectural intelligence! This is evidently *untenable.* Those, however, who explain the architectural instinct of beavers from the hereditary disposition of their sensitive cognition and appetite, are able to explain from the same principle any given modification of their architecture, without resorting to "animal intelligence."

5. *Other Purposes for Which Ants Employ Their Architecture.*

Some ants having populous colonies often establish *temporary stations* at the foot of trees and bushes,

[1]) L. c., p. 377.

where they visit their plantlice and scale-insects to "milk" them by caressing them with their feelers. A few European ants, namely *Formica rufa, pratensis* and *Lasius fuliginosus* build regular streets, clearing away from their path all vegetable growth to a distance of sometimes from 20 to 50 m.[1] These streets lead from their nests into woods and bushes and thence branch off to the pasture-grounds of their "cattle." Other ants, in particular *Lasius niger* and *Cremastogaster scutellaris* build covered roads or tunnels of earth, by which their nests communicate with trees and bushes that are inhabited by aphides or scale-insects. These they occasionally surround with earth-ramparts, in order to keep them together and to protect them from other ants by whom they might be coveted. Such a "plantlice-pavilion," an earth construction the size of a hazel-nut, is in my collection; it was built by *Myrmica scabrinodis* at the top of an oak-twig in the neighborhood of Exaten. Other ants, e. g., the African *Dorylus* species, dig subterranean tunnels, where they go for their prey, consisting chiefly of insects and worms. The harvesting ants of Southern Europe, Western Asia, Northern Africa, America and India establish granaries in their nests, where they store up their provisions for winter or summer. The *Atta* of tropical America, feeding on mushrooms, use a number of subterranean chambers as vegetable gardens and hot-houses, in which the mushrooms

[1]) Among foreign ants there are especially the larger species of the American leaf-cutting ants (*Atta*) which, according to Belt, Brent and Forel, build similar roads, but frequently of a still more considerable length and breadth. The same ant-roads we find in North America with ants of the group of *F. rufa,* especially with *Formica exsectoides.*

are grown.[1] Ants employ their building skill also to protect themselves against enemies. They raise ramparts and barricades to keep off foreign invaders; and unwelcome visitors which cannot be got rid of in any other way, are simply walled up with earth, and are thus kept at a distance. Thus, in one of my observation nests of *F. sanguinea* a salamander introduced by me was in a short time entirely walled in. The slaves (*F. fusca*), past masters in the art of building, were most zealous in this work. An occurrence far more amusing took place in a nest of *Lasius flavus,* to whom I had given a *Lomechusa strumosa* as guest. The small, yellow ants were not at all pleased with the unwieldy fellow, and tried to get rid of his importunity in the following droll manner. From all quarters they brought together pellets of earth and heaped them up on the back of the unfortunate beetle, until nothing was to be seen of him but the tips of his feelers.[2]

Ants are even supposed to have their cemeteries and burial-places. Superficial observers have circulated many fables on this subject. In the book of a certain Reverend White (Ants and their Ways, London, 1883), I found a touching story by Mrs. Lewis-Hutton, of Sidney, which is really too characteristic of this kind of natural history to be passed over in silence. One of her children had sat down on an ant-nest and had been assailed by the enraged inhabitants. At the

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[1]) Moeller, "Die Pilzgaerten einiger suedamerikanischer Ameisen" (Jena, 1893), and *Forel*, "Zur Fauna und Lebensweise der Ameisen im Columbischen Urwald" (Mitteil. der Schweiz. Entom. Gesellsch.," IX, 9th issue), p. 406.

[2]) "Die internationalen Beziehungen von *Lomechusa strumosa,*" in "Biol. Centralbl.," 1892, p. 653.

cries of her child the mother ran to the spot and killed a few score of ants. A short time after she saw the corpses surrounded by a number of their companions. The burial ceremonies began. A deputation of ants was despatched to the nest to fetch the train of mourners. They marched in due order two by two to the scene of disaster. They took up the corpses, marched slowly in procession to a sandy place in the neighborhood and buried them one by one. A few of the gravediggers which tried to escape this doleful duty by flight, were pursued by the other ants, overtaken and summarily sentenced to death. The sentence was immediately carried out, and the criminals were all interred in a common pit. The said lady maintains to have witnessed similar proceedings more than once. Gerstaecker in his "Report on the scientific results obtained by Entomology during the year 1861" mentions this burial story (p. 156) with the following ironical remark: "To render the mystification complete, nothing more was lacking than a funeral sermon held by one of the ants." Strange to say, Perty[1] attempts to defend the imaginative lady against Gerstaecker by saying: "There seems to be some truth in it, anyway, for Dupont also maintains that ants have common graveyards at some distance from their buildings, whither they carry their dead." Ernest André[2] was far more correct about those burial ceremonies of ants in calling them phantastic misrepresentations of the commonest occurrences. It seems scarcely possible, that such an anecdote should see

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[1]) "Seelenleben der Thiere" (2d ed.), p. 328.

[2]) "Les fourmis" (Paris, 1885), p. 176.

the light in a highly scientific publication, in the Transactions of the Linnean Society of London (1861). We are scarcely able to understand, why George Romanes, who incorporated the Australian burial anecdote in his work "Animal Intelligence," did not even in the sixth edition (1895) entertain any doubts about it, but continued to regard it as sufficiently authentic. *Something,* to be sure, was true in the whole affair; but this "something" is confined to the fact that ants remove their dead from their nests to a certain place where they collect all their rubbish, and sometimes cover it with earth. These places, however, would no doubt be far more correctly called "dumping grounds" than graveyards; for they are nothing but places where they deposit everything that displeases their instinct of cleanliness.[1] These phenomena have nothing to do with "Chinese veneration for the dead,"[2] as can be easily ascertained in artificial observation nests. In these nests the dryest spots farthest away from the interior of the main nest are used for collecting the refuse. In my large observation nest of *F. sanguinea* the place bearing the name "refuse nest" is the one in which the corpses of dead ants, remnants of dead flies, wings of dismembered dragon-flies, empty cocoons of ants and other rubbish is finally stored, just because the ants wish to get rid

1) Forel, "Ameise und Mensch oder Automatismus und Vernunft."

2) W. Marshall, in his "Leben und Treiben der Ameisen" (p. 26), says, "the American forms seemed (as regards the treatment of their dead) to be more affectionate than those of the old world." We should like to know why? At least nothing of the kind follows from the observations, which he mentions, of McCook. See "Die Honigameise des Goettergartens" ("Stimmen aus Maria-Laach," XXVII, 1884, 282), where we have dwelt more at length on the "affection" of the American honey-ants.

of such disagreeable objects. It is utterly useless to embellish the life of ants with fabulous anecdotes like that Australian burial story. The cold facts are interesting and wonderful enough.

6. *Is the Architecture of Ants Guided by Intelligence?*

The building instinct of ants proves to be such a universal faculty, and its application to various purposes is in many cases seemingly so intelligent, that we are finally confronted by the question: *Why should we not call this an intellectual faculty?* The following discussion will probably throw some light on the subject.

Would it not be a proof of intelligence, if ants, not themselves provided with spinning glands, employed their larvae for manufacturing threads, by means of which they build a nest of leaves? According to W. D. Holland's observations this is done by a large, reddish-yellow ant of Eastern Asia called *Oecophylla smaragdina*, whose nests he studied in Ceylon.[1] With their mandibles the ants first bring into the proper position the leaves to be connected and keep them there; then others approach in large numbers, each carrying a larva in its mouth, with which they begin to move across the leaves from side to side. Wherever the mouth of the larva touches the leaf, a thread appears sticking to the leaf. This process is continued, until the leaves are attached to one another at their edges by a firm tissue of threads, and finally a viscous, paper-like stuff is formed consisting of innumerable threads crossing each other in all direc-

[1]) *E. E. Green*, "On the habits of *Oecophylla smaragdina F.*" ("Proceedings of the Entomological Society of London," 1896, p. IX.).

tions. These ants use their larvae as *"spinning wheels,"* not only for building their paper-nests, but also, according to Holland, for protecting their nests against the invasions of small ants, with whom they are in continual warfare. Around the trunk of the tree containing their nest they sometimes put a belt a foot broad, formed of threads, which serves to entangle the small ants and prevent them from climbing the tree. In manufacturing this protective tissue the ants come forth from their nest, each carrying a white pellet in its mouth, and move to and fro on the trunk. Upon closer inspection it was found that those little white lumps were again their larvae!

These curious phenomena needed to be corroborated by further investigation. Forel in his "Die Nester der Ameisen" (p. 20) already called attention to the fact that the mandibular glands of *Oecophylla* are strongly developed and possess large and numerous cells. From the analogy with other ant species (*Cremastogaster, Dolichoderus,* etc.), which secrete a certain glue from their mandibular glands for manufacturing their paper-nests, it might seem probable, that the spinning material of *Oecophylla* proceeds from the ants' mouth. But, on the other hand, Professor Chun has recently shown in his splendid book "From the Depths of the Ocean,"[1] that the spinning glands of the *Oecophylla*-larvae are far more developed than those found in other larvae of ants. We must conclude, therefore, that Mr. Holland's statements were quite exact, and that the spinning glands of the larvae, not the salivary glands of the ants themselves,

[1]) "Aus den Tiefen des Weltmeeres," 2d ed., Jena, 1903, p. 129.

deliver the threads employed in the marvelous architecture of *Oecophylla.*

In adopting this supposition, that ants employ their own children as a kind of "spinning wheel," we are confronted by the extraordinary fact that animals make use of an instrument, other than any bodily organ, for building and defending their nests, an occurrence *unparalleled* in the whole animal kingdom, even among higher animals. But can we account for the proceedings of this Indian ant on the score of *intelligence,* that is to say, of her own, individual reflection? Just as little as in the case of the other specific arts and talents of animals; for they are all the hereditary property of certain species, not invented or learnt by independent individuals. And, therefore, also the spinning talent of *Oecophylla,* even if it is done by means of the larvae, is due to *hereditary instinct,* not to the *individual intelligence* of the animal.

To obtain proofs for attributing the architecture of ants to their own intelligence we should have to look for instances, in which, in consequence of individual experience and reflection, these animals modify their innate instincts in such a manner as to *invent new means of accomplishing their purpose.* This is the third form of independent learning, which, as we have shown in a former publication,[1] is a real proof of the intelligence of the learner. We must, therefore, examine, whether the building activity of ants

[1]) In the chapter on *the different forms of learning* in "Instinct and Intelligence" (Herder, St. Louis, 1903). A more detailed discussion of this point will also be found in our publication, "Die psychischen Faehigkeiten der Ameisen" (Zoologica," 26th issue, Stuttgart, 1899), pp. 82-114.

contains any facts belonging to this class of psychological actions.

Patrons of animal intelligence have repeatedly maintained, that ants *build bridges with the intelligent purpose* of overcoming obstacles placed in their way. Even a century and a half ago it was noticed by Cardinal Fleury, that when he tried to keep ants from climbing a tree by smearing it with bird-lime, they gradually covered the bird-lime with earth and thus paved a road across. He informed the famous Réaumur of this observation, who immortalized it in his Mémoires pour servir à l'histoire naturelle des Insectes (1734-1742). And because ants have not become weaker-minded since the days of Réaumur, many other friends of nature had the occasion, from that time on, to observe and to record similar "bridges" built by these insects. One of these reports, best known in recent times, is the following.[1] Professor Leuckart in Giessen (Germany) wishing to keep ants from frequenting a certain tree, surrounded it with a cloth soaked in tobacco-juice. The ants above the cloth upon meeting the impediment turned back and after awhile let themselves drop to the ground from the branches, but those which were ascending to visit the aphides, after having in vain tried to cross the ill-smelling cloth, descended and after a short time were seen coming back, each with a pellet of earth in its mouth. These they pasted over the tobacco-juice, and soon a passable road was constructed. William Marshall recording this observation of Leuckart in his "Leben und Treiben der Ameisen" (p. 40) adds the

[1]) *Buechner,* "Geistesleben der Thiere," p. 116.

following momentous reflections: "All the philosophers together of ancient and modern times, and all the theologians moreover, will not impose upon me by asserting that we have to do here with the action of an *unreasonable* creature. If this is instinct, then the invention of the steam-engine is instinct, too! No, both mean a clever profiting by given circumstances, due to reflection!"

Many an unwary reader may, possibly, be overwhelmed by this spirited appeal to the steam-engine on the part of Marshall. However, if we do not allow ourselves to be imposed upon by the boldness of his oratorical flight, we shall arrive at different results, without being exactly philosophers or theologians. We can observe any day, that on the part of the ants ill-smelling or sticky objects are simply covered with earth, if they cannot be removed from the nest. Nobody will be inclined to maintain seriously, that ants, by so doing, make use of any "intelligent gift of invention" transcending their power of instinct. Outside of their nests also, and governed by the same instinct, they occasionally adopt the same procedure. Now, in the above mentioned case the ants found, that the road which led them to their aphides on the tree, had been covered with an ill-smelling, sticky substance. What was more natural than to fetch pellets of earth and to clear a passage by a method so familiar to their instinct? Hence, we are justified in drawing the following conclusion: *That by this pretended "bridge-building" these ants have given infallible evidence of reflection, inventive genius, and intelligence, is a statement worthy only of popular, uncritical psychology.*

One thing, however, is made evident by these and similar observations, viz.: that ants are not mere reflex machines, but beings endowed with sensitive cognition and appetite, and with the power of employing in the most various manner their innate, instinctive faculties and abilities under the influence of different sense-perceptions. And just on this account it is altogether superfluous to admit "animal intelligence"; for, the complex representations of sensitive cognition, as we have shown in the above example, afford a simpler and better explanation of whatever is not mere fiction in those supposedly intelligent actions of animals.[1]

Another example of bridge-building, which, by the way, is merely vouched for by a Mr. Theuerkauf in Buechner's "Geistesleben der Thiere" (p. 117), is still less corroborative of ant intelligence than the former. In this case the ants used a different means for bridging over a circle of tar smeared around a tree. The ants were descending from the top; on arriving at the obstacle some stuck fast, others returned to fetch plantlice from the twigs; they put them on the tar and thus constructed a bridge. Sir John Lubbock[2] remarks in explanation of this story, that he had his doubts as to the interpretation of the fact. "Is it not possible that, as the ants descended the tree, carrying the aphides, the latter naturally stuck to the tar, and were therefore left there? In the same way I have seen hundreds of bits of earth

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[1]) Cf. on this point, "Instinct and Intelligence in the Animal Kingdom" (1903), p. 109 and 137 ff., where we have shown, that not even higher animals may be credited with formal consciousness of purpose.

[2]) "Ants, bees and wasps" (London).

deposited on the honey, with which I fed my ants." In fact, only trivial observers could maintain that in this case the ants had intentionally employed their aphides as bridge-building materials. The correct explanation might rather be the following: the ants, becoming uneasy about their precious aphides living on the tree, tried to save them by carrying them down. By this attempt, however, the aphides literally "got stuck in the mud." It was, no doubt, *merely by chance,* that the aphides adhering to the tar formed a sort of bridge for the ants.

These two famous stories are, therefore, far from furnishing any evidence in favor of ant-intelligence. We have to investigate other examples to determine whether or not ants are able by "reasonable reflection" to invent new means for fulfilling their designs.

Sir John Lubbock[1] has made a number of experiments with ants in order to test their intelligence; some of the more important only can be mentioned here. For the ants of a nest of *Lasius niger* he arranged a bridge made of a piece of straw or a slip of paper, by which they could get at their larvae. After the ants had become sufficiently familiar with this pathway, he slightly moved the bridge, "so as to leave a chasm, just so wide that the ants could not reach across. They came and tried hard to do so; but it did not occur to them to push the paper bridge, though the distance was only about one-third inch, and they might easily have done so." Another experiment he relates as follows: "I suspended some honey over a nest of *L. flavus* at a height of about half an inch, and accessi-

[1]) "Ants, bees and wasps," Chap. IX.

ble only by a paper bridge more than ten feet long. Under the glass I then placed a small heap of earth. The ants soon swarmed over the earth on to the glass and began feeding on the honey. I then removed a little of the earth, so that there was an interval of about one-third of an inch between the glass and the earth; but, though the distance was so small, they would not jump down, but preferred to go round by the long bridge. They tried in vain to stretch up from the earth to the glass, which, however, was just out of their reach, though they could touch it with their antennae; but it did not occur to them to heap the earth up a little, though, if they had moved only half a dozen particles of earth, they would have secured for themselves direct access to the food." It is evident from this, that the ants had not the least idea of employing even this simple means. In all his experiments Lubbock obtained *entirely negative results.* There was no indication of the much-vaunted intelligence of ants. Strange to say, William Marshall has not mentioned these experiments of Lubbock in his "Leben und Treiben der Ameisen," although they could not have been unknown to him, as he translated them himself into German; perhaps it was, because the results did not fit in with his enthusiastic praise of the "reflective faculty" and "inventive genius" of these animals.

This latter experiment of Lubbock was repeated of late by Albrecht Bethe[1] in a somewhat different form. Over a well-frequented pathway of *Lasius*

[1]) "Duerfen wir den Ameisen und Bienen psychische Qualitaeten zuschreiben?" (Bonn, 1898), p. 66.

niger he fastened a strip of tin with some honey. After the ants had for a long time been allowed to visit the honey, the strip was gradually raised by a screw, until from their pathway the ants could no longer get at the honey. Though it would have been easy enough to heap up a little earth under the strip of tin, it never occurred to the ants to do so; the honey remained beyond their reach. This experiment, therefore, had the very same results as Lubbock's, namely, that the ants were not capable of forming the simplest intelligent conclusion, which would have led them to employ their building skill for the purpose of getting at the honey.[1]

I may add here a few observations and experiments of my own. Since it might be objected against Lubbock's results, that he took for his experiments some ant-species "little endowed with intelligence," namely, *Lasius* and *Myrmica*, I chose the most intelligent ants, namely, *Formica sanguinea*[2] and her allied slaves as subjects for experiments, of which only a brief extract is here presented.

In the front-nest of my above mentioned observation-nest (see p. 23) a piece of wood formed a commodious bridge, over which the ants could pass to the rim of the glass and thence into the top-nest. By their earth-constructions in the front-nest the ants had gradually lowered the bridge, so that the distance

[1]) Bethe infers from this experiment that ants do not even possess sensitive perception and cognition. This inference is too far-reaching, and is owing to his mistaking intelligence for sensitive cognition. See "Die psychischen Faehigkeiten der Ameisen," p. 73.

[2]) Forel also ("Fourmis de la Suisse," p. 443) states that *F. sanguinea* deserves the palm for intelligence.

between the top-end of the bridge and the cork of the glass was about 2 cm. When exposed to the sun the inside of the glass was generally covered with moisture, and the ants found great difficulty in passing the intermediate space and in getting into the top-nest. Although this state of affairs lasted for weeks, and the ants continued to encounter the same difficulties, it never occurred to them to connect the broad, upper end of the stick with the roof of the front-nest by a bridge of earth. They connected the sides of the stick with the glass by a wall of earth; gradually they also covered the whole glass-wall with pellets of earth to protect themselves against the rays of the light; but they *never* built a bridge at the critical spot, where one was evidently needed and of the greatest importance. The pellets of earth accidentally fastened there were, on the contrary, continually thrown down by the ants that crawled up the road. Thus exactly that spot over which the ants, if they were endowed with any *power of thought and reflection,* would be expected to build a bridge, was left slippery and smooth, and was still the same after half a year.

In 1884 I repeatedly made the following experiment: In a tiny vessel I suspended some honey or ant-larvae over a nest of *F. sanguinea,* contained in a large "crystallisator",[1] so that the ants could touch the vessel with their antennae only, but could not reach it except by a very circuitous route. It should have occurred to them to heap up a little earth or some pieces of wood underneath the vessel, in order to form a "bridge" leading directly to the wished for goal.

[1]) A low, round glass bowl, covered by a glass plate.

But neither the *sanguineas* nor their slaves (*F. rufa* and *fusca*), living in the same nest, ever hit upon this obvious method, although it would have sufficed to raise the surface of their nest at the spot in question just by 1 cm.!

A more wonderful result was obtained in another experiment on the same nest of *sanguinea*. On June 16, 1884, I filled a large watch-crystal with water and in the center upon a kind of island I placed a little shell filled with ant-cocoons previously taken from the same colony. This artificial pond with its island was then introduced into the nest. The ants soon noticed the cocoons and stretched out their feelers towards the island; but getting into the water at every attempt to approach, they retreated again and again. I began to think they would never be able to overcome the difficulty, when suddenly a *sanguinea* began to throw into the water pellets of earth, bits of wood, dead ants and similar solid materials. Others followed her example and *they soon had built a road over the water!* In the space of an hour, counting from the minute I started the experiment, they had fetched all the cocoons from the island by means of this "floating bridge." The very last cocoon having been secured by the ants, one of them returned to the island and, finding it empty, she squatted on her haunches, passed the spur of her fore-feet through her mouth and then combed her feelers with the spur, sitting there for several minutes in a most provoking attitude, as if she were saying to me: "Ah, my dear, who has won the game now?"[1] Is this fact not a staggering proof,

[1]) This very last instance, as many others in this translation, was added by the author from his original notes.

that at least the *sanguineas* are endowed with a good quantity of reflective power and of intelligent consciousness of purpose?

In order to answer this question I tested the above observation by the following experiment: After some time I again placed the same watch-crystal filled with water in the nest, but this time without island and without cocoons. Now, supposing that the ants in the previous case had really intended to build a bridge for the sake of getting at the cocoons, there was no longer any reason for them to repeat the procedure. However, this second time also, after several had accidently got their feet wet, they soon started to fill up the lake. Although this time there were no cocoons to be obtained, nor any island in sight,[1] yet they again covered the water with all kinds of materials in the same manner and almost in the same space of time as they had done before. Hence, we are allowed to conclude, that even the first time the ants had not intended to build a floating bridge, but only to get rid of the disagreeable moisture that barred their way. If, therefore, we maintained, that in the first experiment *the ants had by intelligent fore-thought invented a means for regaining possession of their cocoons,* we would be guilty of uncritically humanizing the brute.

From all the observations made and noted down for

[1]) I wish to lay emphasis on this circumstance, because Prof. Charles Sajó (in "Prometheus," 1899, No. 486, p. 284) believes the ants had hoped to find some treasure on the island this time also. The ants could easily notice from the margin of the watch-crystal, that there was no island. The eyes of *F. sanguinea* being rather large and sharp and capable of distinguishing the form of small objects at a distance of several centimeters, the ants could undoubtedly see that there was no island.

the last twenty years, I could record here still many an interesting occurrence, which, like the above example, impresses a superficial observer as an intelligent action. Yet, closer examination invariably proves that such facts are accounted for much more easily and naturally by the instinctive combinations of sense-representations; therefore, *no "ant-intelligence,"* and in fact *no "animal-intelligence" at all* is required.

Indeed, the higher mammals ranking next to man in brain development are far from supplying more convincing proofs of "intelligence" than ants. In them also the whole process of cognition is confined to the mere connecting of sense representations and sense experiences according to the inborn laws of instinctive association of representations, which ordinarily regulate their lives. The psychic endowments of dogs and monkeys go no farther. Unless a dog has been specially trained, it never occurs to him to open a door, the knob of which he is unable to reach, by fetching for instance a foot-stool to gain a higher level; he may have seen children, his play-fellows, doing the same thing a hundred times; the relation between means and end, though so natural and obvious in this case, will forever remain hidden to the canine soul. Hence the dog is not a whit more intelligent than the ants, that failed to notice, that a little heap of earth would have sufficed to secure them an easy passage to the honey suspended in a saucer above their nest.

Neither do apes possess the power to invent by their own reflection new means of accomplishing their end. Even these highest mammals are confined ex-

clusively to the instructive association of sense-representations. We have shown this in our first chapter, where we discussed the wars that take place in the animal kingdom, and pointed to the fact that apes are unable to invent the simplest weapons and implements even. The same holds good as to the use of fire. If a troop of apes in the forest hits upon the remnants of a fire lighted by the hands of man, they will certainly gather around it and enjoy the comfortable warmth. But it has never, hitherto, occurred to any ape to supply it with fuel.[1] And yet it would be such a simple and natural combination of representations, requiring but a low degree of intelligence. Why do apes, in spite of the "high plasticity" of their quasi-human brain, never hit upon such a simple means? *Because they possess no spiritual soul and therefore no intelligence.* The "plastic neurozymic activities" of the simian brain are essentially different from human intelligence; like those of ants and all lower animals they prove to be functions of mere sensitive instinct. It is wrong, therefore, to describe ants as instinctive automatons, in order to safeguard the intelligence of the higher animals. The psychic actions of *all* animals are due to automatism, as far as they are unable to attain the level of reasonable reflection and free self-determination. For the rest, however, there is no question of automatism either with lower or with higher animals, because it is sensitive cognition and not mere reflex activity, which prompts them to act. It is true, that instinctive actions have a certain auto-

[1]) Cf. Tylor (in *Ranke*, "Der Mensch," II, 1st ed., 436) and Charles E. v. Baer (in *Stoelzle*, "Karl E. v. Baer und seine Weltanschauung," pp. 304, 314).

manic character, inasmuch as they are, to a certain degree, predetermined by the natural constitution of the animal. However, inasmuch as they are governed by sensitive cognition and appetite and, therefore, capable of more or less *modification* within the predetermined natural limits, they are not of an automatic, but of a spontaneous character.

In conclusion, let us sum up the results of our comparative discussion on architecture in the animal kingdom. They are: *Ants surpass all animals, both lower and higher, by the quasi-intelligent variability, the spontaneous self-determination and the power of suitable adaptation, manifested in their architectural skill. Nevertheless it is as certain of them as of any other animal, that they are not endowed with intelligence properly so called.*

This corroborates the views advanced in our discussion on the *different forms of learning*.[1] Ants are able to accommodate their buildings to the most varied conditions; hence they are able to "*learn*" how to modify their buildings according to given circumstances. But this learning takes place *only in so far as* sense-experience gives rise to new combinations of representations; as soon, however, as the modification of their activity would require *intelligent reflection, or the drawing of conclusions from former conditions to the present ones*, then both ants and higher animals, without exception, are all at once *incapable of further learning*. This shows to evidence, that the doctrine of "animal intelligence" is utterly untenable.

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[1] "Die psychischen Fähigkeiten der Ameisen" pp. 82-111, "Instinct and Intelligence in the Animal Kingdom" (Herder, St. Louis, Mo., 1903), Chap. VIII.

CHAPTER IV.

CARE OF THE YOUNG IN THE ANIMAL KINGDOM.

1. *A General View of the Breeding Instincts of Animals.*

HUMAN community life naturally evolves from the family, which must always remain the foundation of the state. Animal societies have a similar origin and basis, though this similarity does not go beyond mere analogy. Wherever we meet permanent associations of animals, they are seen to depend, with very few exceptions, such as for instance the mixed colonies of ants, on the ties of common descent. The purpose of this social co-habitation is the preservation of the race and species. All other animal instincts are by natural law subordinated to that higher end, which is also the reason for the existence of social instincts of animals.

One of the most important means for preserving the species is breeding, with the various instincts subservient to it. The different forms of breeding in the animal kingdom form one of the most interesting chapters of comparative animal psychology; in this place, however, we must confine ourselves to some of its more prominent features.

With those lower animals, which reproduce without sexual generation by fission or by budding, there can be as little question of breeding instincts as with

plants. The new being comes into existence already fully endowed with the power of subsistence according to the laws of merely vegetative nature, whether it be separated from the mother-organism, or remain united with it as a new part of a polyzoal colony. Here, therefore, it would be altogether useless to possess breeding instincts for the propagation of the species. Even among such animals as propagate through sexual generation, we meet with breeding instincts only where they are required for the preservation of the species; and the parents care for their offspring only in as far as it is necessary for that purpose. Within these limits, however, we find a wonderful adaptation of means to the end, and at times a marvelous sagacity of animal instinct, which appears nowhere else to such advantage.

But also nowhere else in the whole animal psychology are manifested so palpably the impotence of so-called animal intelligence and the unsoundness of the modern tendency of humanizing animal life. How should the ephemera know by her "own intelligence," that she may without any apprehension drop her eggs into the water? Does she perhaps still remember, that her "mother" once upon a time dropped her also into the water as an egg? Or has she perhaps by the study of zoology gained the knowledge that ephemeras need no hatching? According to Brehm's psychology we ought to give the ephemera a thorough scolding for showing so little motherly love towards her dear offspring and for not caring for their welfare. But scientifically speaking, such a scolding is as nonsensical as if we were to blame an oak tree for bearing

acorns instead of pumpkins, or a hen for laying eggs instead of begetting live chicks. Ephemeras flit about over stagnant pools and drop their clusters of eggs into the water; pearl-flies carefully attach their eggs to a flimsy peduncle consisting of a sap hardened by exposure to the air; ichneumon-flies deposit their eggs in the body of a caterpillar by means of their ovipositor; gall-flies introduce theirs under the rib of an oak leaf, from which later on the gall-nut is to grow, serving both as dwelling and as provision store of the young larva; the blue-bottles place their eggs on putrefying flesh, whereas a certain species of wasps (*Pompilus viaticus*) glue theirs to the bodies of spiders which they paralyze by skilful thrusts of their sting without killing them, so as to enable the growing larvae to feed upon live flesh; the common cabbage-butterfly deposits her eggs on cabbages, the hawk-moth on poisonous spurges, the large clavicorn water-beetle (*Hydrophilus piceus*) weaves for its eggs an ingenious boat with a little streamer on top to float about on the surface of the water, whilst a smaller allied species (*Spercheus emarginatus*) carries its eggs, as many spiders do, in a bag attached to its abdomen; the leaf-rolling beetle (*Rhynchites betulae*) cuts a birch-leaf in a manner implying a difficult problem in applied mathematics, and rolls it up into the shape of an ingenious funnel, in which it deposits its eggs; whilst *Rhynchites pubescens* saws a cradle for its eggs in the wood of an oak-twig, the ear-wig hatches its eggs like a hen, whilst *Lomechusa strumosa*, just like cuckoos, confides its brood to the care of ants; they all do their duty with equal prudence, but all too are

ignorant of the prudence of their actions, and unconscious of duty. Under the guidance of sensitive cognition and perception they follow the mysterious instinctive impulse arising from their organic development, which suggests to them the means necessary for preserving their species. But they do not understand the appropriateness of these means and need not reflect how to use them to advantage.[1]

Wherever in the animal kingdom the care of the young requires "family life," i. e., a regular co-habitation of the parents and of the young, this task takes place only as far as the preservation of the species renders it necessary. The same organico-instinctive laws, to which breeding is subjected in general, also determine the existence and firmness of family ties as well as the extension of the family circle with different species of animals. There is no room for individual reason and liberty; and to postulate them is not only wholly superfluous, but also contradicted by innumerable facts. As birds associate in pairs only during the mating season for the preservation of the species, so in building their nest and in hatching their young, the two mates co-operate likewise only as far as is necessary for preserving their species; and the pairs remain together and in company with their young no longer than the same purpose requires. Altum, in his excellent book "Der Vogel und sein Leben", has supplied us with a number of striking instances, proving how ridiculous and unten-

[1]) We have so minutely proved this fact in the case of insects that live single, in our book, "Der Trichterwickler, eine naturwissenschaftliche Studie ueber den Thierinstinct" (Chap. IV. ff.), that there is no need of repeating the proof here.

able it is to apply to birds the notions of marital and maternal affection as it exists among men. As a matter of fact, there is no more "marital affection" in the *human* sense of the term to be found with a loving couple of parrots than with spiders, where the smaller male must be on its guard not to be devoured by the larger female immediately after mating. And by devouring her "husband" the female spider sins as little against morals, as she acts conformably to them in carefully protecting and carrying along her egg-bag or in spinning a protecting web for her young. And the female cuckoo smuggling her eggs into nests of strangers acts as little against morals, as the foster-parents of the young cuckoos act conformably to morals in feeding and rearing these changelings. There is no room for reason and morality in the breeding instincts of animals; for they are *exclusively* determined and regulated by the laws of organico-sensitive life.

The same holds good for mammals, the anthropoid apes not excepted. As long as young dogs, cats, and apes need the care of their parents, they will not be forsaken. But no sooner are they old enough to shift for themselves, than their parents no longer know their once so "beloved" offspring. As the mates know each other only for sexual intercourse, so also they know their young only as helpless beings, whose behavior stimulates the nursing instinct of their parents to action. As soon as this instinctive impulse ceases, then the mates and the young are completely estranged, having no regard for each other in the relentless struggle for existence, for food and rut, just as if

they had never belonged together. This is a *general law of nature,* ascertained by science *throughout the whole animal kingdom,* setting at naught all the fine phrases and sentimental talk of Brehm on marital and parental love among animals. And this gush, the outcome of erroneous notions and misplaced sentiment is dubbed by thousands of its votaries *modern animal psychology!*

Care of the young in its most primitive form is found among the *Echinoderms,* namely in a few species of star-fishes (*Asterias Muelleri, rugispina, Cribrella oculata*).[1] According to Perrier the female animal, by bringing her arms near to the body, forms a kind of breeding cavity, in which the young, huddling together, are enclosed. In the different classes between the *Echinoderms* and the vertebrates care of the young assumes very different forms, which we are unable to discuss here. Of peculiar psychological interest, however, are those animals, among whom the *males* and not the *females* are entrusted with the care of building nests and rearing the young. The best-known example of this kind among fishes is the stickle-back (*Gasterosteus aculeatus*).[2] In this species the females are regular "cannibal stepmothers," whereas the males are models of "affectionate fathers." How ridiculous such facts are, when couched

[1]) See *H. Ludwig,* "Sitzungsber. der Niederrh. Gesellsch. fuer Naturk." (Bonn), 1896, 1st half, p. 104; besides in "Zoolog. Anzeiger," 1897, No. 534, p. 217 and No. 535, p. 237.

[2]) Also among amphibias cases of male hatching have been ascertained. See *Fr. Werner* in "Verhandl. der Zoolog.-botan. Gesellsch. von Wien," 1898, 1st issue, p. 11 ff. See also *R. Wiedersheim,* "Brutpflege bei niederen Wirbelthieren" (Biolog. Centralbl. XX, 1900, Nos. 9 and 10).

in anthropomorphic language, goes without saying.[1] Some instances of taking care of the young occur also among amphibias. The female of the Surinam toad (*Pipa dorsigera*) carries her young in the cavities of her dorsal skin; whereas in a frog species (*Arthroleptis seychellensis*) inhabiting Central America the young hold on to the back of the male.[2] But quite universal and commonly known is the care bestowed by birds and mammals upon their young. Yet its highest perfection, connected with the most perfect form of community life in the animal kingdom, does not occur with the higher mammals, but with the *social insects,* in particular with *ants.* Here this degree of perfection is made possible by the organic division of the female sex into females proper and into nurses (workers) incapable of generation. And although these are not the mothers of the children they nurse, the *psychic development* of their breeding instinct reaches the greatest perfection in the whole animal kingdom. Before discussing, however, this aspect of the breeding instinct of ants, we must first explain its connection with the laws of their organic development.

The bodily differentiation of the members of an insect-state into classes and castes, their co-habitation in a common abode, their nest-construction, acquisition

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[1]) The following amusing quotation will do for the purpose: "The greatest danger threatens him (Mr. Stickleback) from the mothers of his own children. Eager to devour their own offspring, they are continually dashing in unison against the nest, in which the young are guarded by their watchful father, and but too often the latter pays the penalty of his polygamy" (*Thilo,* "Umbildungen an den Gliedmassen der Fische," in "Biolog. Centralbl.," 1897, 1st issue, p. 24).

[2]) "Zoolog. Jahrb. Abth. fuer Systematik," XII (1898), 89 ff.

of food, their whole life and activity have for their object the care of the offspring, and thereby the preservation of the species. The animal colonies of bumble-bees, wasps[1] and hornets represent a lower stage of community-life, than the perennial colonies of honey-bees, ants and termites. In the case of the former the insect-families and the entire community-life have to be established anew every year by some hibernating female; but with the latter the original families last several years and often much longer, thus giving their community-life a character of stability and also of greater variety and perfection.

The organic foundation of insect-states, as already shown above (p. 14), is *polymorphism*, or the separation of the individuals into sexual animals and "neuters"[2] or workers. The prime duty of the former is generation, this being the direct means for preserving the species, whilst the latter perform all the work required for the welfare of the family, thus in their turn indirectly contributing to the same end. Without this appropriate division of labor insect-states would be impossible; and, as a rule, the more perfect this division, the more perfectly developed is the insect community.[3] In bees, with whom the workers are

[1]) According to *H. v. Jhering* ("Zoolog. Anz.," Vol. XIX, 1896, No. 516, p. 449) a large number of the Brazilian social *Vespidae* (*Polybia, Chartergus*, etc.) form perennial colonies for several years, not annual ones as our native wasps.

[2]) We have already in Chap. I, No. 2, referred to the fact, that in reality they are not, properly speaking, sexless.

[3]) The greatest importance must be attached in this place to the differentiation between sexual individuals and workers. Thus e. g. in the annual colonies of bumble-bees there is a dimorphism of workers, and hence a more marked division of labor than in the perennial colonies of our honey-bee. (On the bumble-bees see esp. *E. Hoffer's* excellent observations on the bumble-bee of Styria). Nevertheless the bee-states are more perfect than those of the bumble-bees on account of the greater difference between their workers and genuine females.

winged and not unlike the real females, polymorphism and, in consequence, community life is less differentiated than in ants, where the neuters are devoid of wings and,—with many species,—are again divided into different castes, namely, workers and soldiers. The greatest variety of bodily differentiation, however, obtains in termites, which belong to the insects with imperfect metamorphosis. In their case the larva resembles the imago and is transformed gradually with little change of outward appearance. Thereby termites present the organic foundation for a still more abundant and variable division of castes, the formation of which may embrace not only sexual individuals on the one hand, and workers and soldiers on the other, but within these two categories again several different classes or forms.[1]

Not even the most ardent defenders of modern animal intelligence would venture to attribute polymorphism, which is the fundamental law in the constitutions of insect-states, to the "intelligence" of the animals themselves. It is evidently based on the hereditary laws of organic development. Just as it is not owing either to his own intelligence or that of his

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[1]) Cf. *Hagen,* "Monographie der Termiten" ("Linnaea Entomologica," X-XIV); *Grassi e Sandias,* "Constituzione e sviluppo della Società dei Termitidi," Catania, 1893. ("Atti dell' Accademia Gioenia di Scienz. nat.," 4, VI and VII); *Wasmann,* "Einige neue Termiten aus Ceylon und Madagaskar," in "Wien. Entom. Zeitung," 1893, 7th issue; "Neue Termiten und Termitophilen aus Indien" ("Annali del Museo Civico di Stor. nat. di Genova," 2, XVI, 1896, 613-630); "Termiten von Madagaskar und Ostafrika" ("Verhandl. der Senkenberg. Naturf. Gesellsch.," XXI, 1897, 1st issue); *G. D. Haviland,* "Observations on Termites" ("Linnean Society's Journal, Zoology," Vol. XXVI, pp. 358-442). *Dr. F. Silvestri* "Ergebnisse biologischer Studien an suedamerikanischen Termiten" ("Allg. Zeitschr. f. Entomol.," VII, No. 9 ff.).

"mammy," that a young rooster became a rooster and not a jackdaw, so no intelligence of the ant is responsible for the fact, that from the egg and the larva which she nurses, there emerges not a bee but an ant. All this is self-evident. Yet, the peculiar organic laws of development not only form the *material* of the breeding instincts, but also their *directing principle.* The breeding instincts of the different species are so well adapted to the hidden laws of organic growth, that no reflection or intelligence on the part of the animal, nay, not even the keenest human reason could ever succeed in inventing them. Moreover, they are exercised by the workers completely and perfectly, without previous experience or instruction; they are innate in the animal, and grow with it, and when the young ant has reached the perfection of its organic development, they, likewise, are just as perfectly developed. Hence they must spring from the same source as the organic growth, that is to say, they spring from the *organico-psychic laws of development* of a given species, and have nothing to do with individual reason and free determination. As it is by organic development, that the male of an ant-species receives also the psychic endowment of a male, thus it is with the females and the workers. The distribution of psychic endowments in the different castes of an ant-state is regulated by the same laws as their bodily polymorphism. And this alone accounts for the fact, that within one and the same species the males are the most stupid members of the whole state, possessing the smallest brains, whilst the workers are endowed with many marvelous instinctive talents and

even surpass the females proper in perfection of instincts and brain development.[1] Those females, which are destined for generation, are provided by their organic development with perfect ovaries, whilst their brain and instincts are far less perfect. The workers, on the other hand, which on account of their small ovaries may be called undeveloped females, are compensated by a more perfect development of the brain and the instinctive endowments. Hence, the astonishing prudence displayed by the worker ants and their consequent social leadership are merely a *function of their organic development.* This is the so-called "intelligence" and "intellectual life" of ants, viewed in the light of genuine science!

We have thus far been considering the breeding instincts of ants from their *organic* side; let us, in the subsequent discussion, turn our attention to their *psychic* aspect.

2. *Care of the Young among Ants.*

The hereditary disposition of the sensitive cognition and appetite of animals, called *instinct,* has in the case of ants a wide range and great variety of actions, and especially so with regard to the breeding instincts, wherein ants surpass even the highest mammals. The instinctive disposition is no mechanical automatism,

[1]) As to the peduncles of the ant brain, the significance of which with regard to psychic life we have already pointed out in a former essay, Forel says: Les corps pédonculés sont énormes chez les ouvrières du genre *Formica,* qui renferme les fourmis les plus intelligentes; et, chose très remarquable, ils sont plus petits chez les femelles et beaucoup plus petits chez les mâles du même genre ("Fourmis de la Suisse," p. 123). My own observations confirm Forel's statements; see "Instinct and Intelligence in the Animal Kingdom," p. 130 ff.

but is guided and influenced by various sensitive affections and perceptions. In bee-hives the eggs are simply deposited by the queens in the cells previously prepared by the workers, and the young bee-larva goes through the successive stages of development in one and the same cell. With ants breeding shows far greater variety and independence. The eggs laid by the queen are received by the workers and gathered in clusters of various dimensions. Then from all sides they are licked again and again with the utmost care, and begin to increase by the endosmosis of the nourishing juice.[1] This is the first stage in the rearing of the young in ant-communities. As soon as the egg has developed into a larva, there follows the second, the feeding and nursing of the larvae. When the time for entering the state of a pupa has arrived, the ant-larvae are carried by their nurses to a spot covered with damp earth, whereupon each larva is surrounded by a case or little dome of earth, within which it spins its cocoon, enwrapping the whole body. From time to time some worker comes to see, whether the cocoon is finished. As soon as it is, it is carefully cleansed of adhering earth, and is then stored up in a neat little heap in company with others that have reached the same maturity. With those ant-species, whose larvae do not spin cocoons, the larvae are not encased in earth before their pupation. On that account the extremely tender skin of the pupa unprotected by a cocoon requires all the more care and caution, lest grains of sand or mould should enter between the

[1]) On the growth of ant-eggs see *Forel*, "Fourmis de la Suisse," p. 388; it is of minor importance, whether or not the increase in volume of ant-eggs be called growth in the proper sense of the term.

tiny segments of the body, or lest in transportation any part of the soft pupa be too sharply pinched by the hard mandibles of the ants, which in this case serve as hands.

It requires a great deal of attention and skill on the part of the workers employed in nursing, only to keep neat and clean thousands of eggs, larvae and pupae. In earth-nests the moist, soft skin of these small beings is in continual danger of being soiled by sand or other foreign matter, and, besides, it is excellent soil for the growth of injurious fungi. Nevertheless, the ants always keep their brood perfectly clean so that even under a magnifying lens not a speck of dust can be discovered. In spite of the damp and mouldy atmosphere, they are able to prevent entirely the growth of fungi both on their brood and throughout the nest. It might perhaps be suggested, that this is, for the most part, to be attributed to the antiseptic effect of the formic acid contained in the poison glands of the ants. But, in reality, the chambers in which the larvae are kept, show an alkaline reaction, as was of late pointed out by Ch. Janet,[1] who explains this phenomenon from the fact, that the secretion of the epidermic, and especially of the salivary glands of ants is of a basic nature.

The cleaning of the young is only a secondary occupation in the ant-nursery. But even in this secondary office the ants surpass all other animals in care and skill. No cat by licking will wash her kittens with such exactness and affectionate attention, as ants

1) "Réaction alcaline des chambres et galéries des nids de fourmis" ("Extr. des Comptes rendus hebdomadaires de l'Acad. des Sciences," CXXVII, 1898, 130).

clean the larvae entrusted to them. Therefore we are right in expecting, that the same perfection of the breeding instincts of ants will be manifested also in the other branches which are not less important for the preservation of the species, namely, in the suitable regulation of the temperature and in the proper nourishment and defense of the brood.

In the care of the young it is of the utmost importance to regulate the conditions of temperature in a manner most advantageous to this development. In bee-hives the position of the brood is determined by the shape of the comb. Throughout its development the young bee remains in the same cell, in which it was placed as egg, and it is therefore constantly subject to the same conditions of temperature. It is quite different with ants. Here the temperature has to be altered and regulated by the workers according to the different stages of development. The eggs and the larvae in their earliest stage are generally stored up in the lowest chambers of the nest, where the air is cool and damp. Further above the half-grown larvae are lodged, whilst the uppermost stories are occupied by the full-grown larvae and the pupae; for these latter require for their development greater heat, which is found immediately beneath the surface of the nest struck by the rays of the sun. If out of doors it grows chilly and rainy, the pupae and elder larvae are immediately carried into the lower chambers, where they are better protected from cold and moisture. This regulation of the conditions of temperature alone, according to the necessities of different stages of development, implies astonishing sagacity, such as even

men would be able to acquire only after years of observation and study. Yet, in ants every single worker is endowed with it as soon as she is drawn from her cocoon and has become dry. This is because their sagacity is *instinctive,* essentially different from intelligence and reflection. Ants are in their every action guided directly by sensitive perceptions, not by intellectual ideas. The enigma, therefore, is satisfactorily explained by the innate adaptation of their sensitive cognition and appetite, whereas the hypothesis of animal intelligence is unable to offer any solution.

But now we come to the most puzzling and mysterious question in the nursing of ants, namely, the *influence of the education of the young larvae on the development of different castes in ant-states.* Science has but just now begun to divine the mysteries hidden here; but it is still far from having fathomed their depths. We shall very briefly place before our readers what is certain or at least probable concerning this matter. It will fully suffice to prove, that the nursing instincts of ants, bees and termites are far superior to those of birds and mammals.

According to the older opinion, thus far commonly held, and based chiefly on Dzierzon's classical observations on bees, the sex of their posterity is determined by the instinctive choice of the oviparous queen, and not by the workers that rear the brood. Because it has been observed, that with ants, bees and wasps unfertilized eggs produce males only, it is assumed that also the normal males of these social insects are always hatched from unfertilized eggs. The queen, when depositing her eggs, is supposed, by either open-

ing or closing the connection between the oviduct and the seminal vessel, to control, under the influence of her oviparous instinct, the fertilization of the egg, and therefore to decide, whether it would develop into a male or a female. This instinct of the queen is aroused to suitable activity by the peculiar nature of the cell, into which she puts her head before oviposition; in drone-cells she puts an unfertilized egg, in those of a future queen or worker a fertilized one. Probably she is led to make this difference not so much by the touch-perception of the different shapes of the cells, but rather by the smell of the salivary gland secretions employed by the workers in their construction.[1] The peculiar odor of the cells, however, as well as their size and form is due to the architecture of the workers; thus, in bees the sex of the offspring is *indirectly* at least controlled by the instincts of the workers. With ants it is different, because their queens do not deposit the eggs in cells, but simply suffer them to be received and carried away by the workers. The instinctive self-determination of the oviparous female seems, therefore, to be greater with ants. Of course, it is very probable, that the nourishment and treatment of the queen on the part of the workers indirectly also influences the oviposition; but in what manner, is as yet entirely unknown.

To pass from the queen to the workers, it was ascertained long ago, that, with social wasps, bees and ants, also workers, which have small ovaries with a reduced number of ovarial tubes, and are, besides, unable to

[1]) Cf. on this point *N. Ludwig*, "Futtersaft oder thierische Veranlagung," p. 32; and p. 57 of the publication of *Ferd. Dickel* mentioned below.

mate, nevertheless sometimes lay eggs capable of development. This phenomenon has been called by Ch. v. Siebold,[1] to whom we are specially indebted for its discovery, virgin-generation, or parthenogenesis. Under natural conditions parthenogenesis occurs with ants principally in colonies which have lost their queen, and therefore try to rear their posterity from eggs laid by workers. In several observation-nests of *Polyergus rufescens*, *Formica sanguinea* and *rufibarbis* the queen was missing, and I observed that the workers,—with *Polyergus* the slaves,—selected an extra large worker of the dominant species as a substitute for the queen, treated her with greater care, gave her more food, and thus induced her to parthenogenetic oviposition. This shows that under certain circumstances the instinct of ants is able to effect by special treatment the development of the ovaries of even adult workers, so as to make them capable of laying eggs;[2] but these unfertilized eggs can only produce

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[1]) "Wahre Parthenogenese bei Schmetterlingen und Bienen," Leipzig, 1856. Quite recently *Ch. Janet* has discovered parthenogenesis also among hornets (Sur Vespa Crabro, Extr. des Mém. de la Soc. Zool. de France, 1895, p. 75).

[2]) This form of parthenogenesis, which is spontaneouly caused by the workers themselves, must be carefully distinguished from another form caused by artificially raising the temperature, and quite independent of the ants' instinct. See my observations in "Biolog. Centralbl.," XI (1891), No. 1: "Parthenogenesis bei Ameisen durch kuenstliche Temperaturverhaeltnisse." The experiments made by *E. Bickford* ("Ueber die Morphol. und Physiol. der Ovarien der Ameisen-Arbeiterinnen," in "Zool. Jahrb. Abth. fuer Systemat.," IX, 1895, 1st issue) with *Lasius fuliginosus* (p. 19; Sep., p. 23) belong rather to the second category than to the first, since she too employed artificially raised temperature. At any rate, they do not approach natural conditions as closely as my observations mentioned above. On the latter cf. "Stett. Entom. Ztg.," 1890, pp. 303-305, and "Biolog. Centralbl.," 1895, pp. 609 and 610.

males.[1] This phenomenon manifests the marvelous sagacity and quasi-intelligent plasticity of animal instinct, which can hardly be styled "automatism." Neither can it be identified with intelligence properly so-called, for this would suppose rational knowledge of the internal laws governing the growth of the ant-organism, a knowledge far surpassing even the intelligence of man and entirely beyond the reflections and experience of ants. Only the appropriate disposition of their sensitive cognition and appetite can account for the fact, that the perception of a given want is followed by a corresponding modification in their nursing instinct, by which the defect in question is remedied.

According to Dzierzon's views, which we mentioned above, it is the oviparous instinct of the queens, that controls the sex of the bee developed from a given egg; in this supposition the worker-bees are assigned a merely indirect influence. Of late, however, another theory on the differentiation of castes in bees has been advanced, which assigns to the nursing instincts of the workers a far more extensive sphere of action. The originator was an Italian priest, Lanfranchi by name, who published it in 1894 in the "Apicoltore." In Germany it was developed and confirmed by new experiments, principally by Ferd. Dickel,[2] the editor of the "Noerdlinger Bienenzeitung."

[1]) More recently *H. Reichenbach* has published some observations (in "Biol. Centralbl.," 1892, p. 461 ff.) which seem to prove, that with *Lasius niger* the parthenogenetic eggs laid by workers may give origin also to workers. But further confirmation will be required before accepting this statement. In North America Prof. W. M. Wheeler has lately published some interesting reports on parthenogenesis in ants.

[2]) "Das Princip der Geschlechtsbildung bei Thieren geschlechtlicher Fortpflanzung, entwickelt auf Grundlage meiner Bienenforschungen." Noerdlingen, 1898; cf. especially p. 20.

Dickel says: "Under normal circumstances the fertilized mother-bee lays only fertilized eggs; it is the workers, that influence and control the fate of these homogeneous eggs." According to this new opinion, also those eggs, which in normal bee-hives produce drones, are fertilized; and not only the differentiation between queen and worker, but between queen and drone, and between worker and drone, is due to the influence of the salivary gland secretions of the workers on the eggs previously deposited in the cells. Hence, Dickel regards both queens and drones only as the *foundation* for the development of the sexes, the workers, however, as the really *determining* factors. According to Dickel, certain salivary glands of the workers contain the secretions determining the sex, and the differentiation of all the castes in bee-hives depends on the instinctive application of these secretions, when the workers are licking the eggs.

Although several biological experiments of other authors seemed to confirm the theory that under normal conditions all the eggs in a bee-hive are fertilized,[1] we must add, nevertheless, that the very exact microscopical studies of Paulke and Petrunkewitsch on the existence or non-existence of spermatozoids in the eggs of bees rather corroborate the old theory of Dzierzon, according to which the eggs giving origin to drones develop without containing any spermato-

[1]) Cf. *N. Ludwig,* "Neues ueber Ernaehrungs- und insbesondere ueber Fortpflanzungsverhaeltnisse der Honigbiene" ("Natur und Offenb.," XLIV, 1898, 12th issue, pp. 705-719), "Weiteres zur neuen Lehre ueber die Geschlechtsbestimmung der Bienen" (ibid. XLV, 1899, 3d issue, pp. 140-148; "Weitere Ergebnisse ueber die Fortpflanzungsverhaeltnisse der Biene" ("Natur und Offenbarung," 1901, 7th issue, pp. 426-430).

zoids.[1] It is best, therefore, to suspend our judgment on this problem, until it is definitely solved.

If the new theory of the fertilization of *all* the eggs in a bee-hive, under normal conditions, should prove true, it ought to be extended also to the ants. Hence, in ant-colonies, too, it would be the workers, who by their nursing instincts determine, whether a given ant-egg is to produce a worker, a winged female, a soldier, or a male.

We intend here, however, to consider only the wonderful influence exercised by nursing on the differentiation between females and workers. This is an established fact, quite independent of the new theory. Why is it that one and the same kind of egg now produces a queen with complete power of generation, now a worker devoid of generating powers, but compensated, as it were, for this loss by psychic endowments all the more perfect? Here we enter a mysterious region, where the breeding instincts of social insects reign supreme, an instinct which for its creative power is unparalleled in the entire animal kingdom.

It is a well-known fact, that with honey-bees a worker larva can be developed into a queen by increas-

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[1]) *W. Paulke,* in "Anatomischer Anzeiger," Vol. XVI, 1899; *A. Petrunkewitsch,* "Die Richtungskörper und ihr Schicksal im befruchteten und unbefruchteten Bienenei," ("Zool. Jahrbuecher," Abtl. fuer Anatomie, Vol. XIV, 1901); *Aug. Weismann,* "Ueber die Parthenogenese der Bienen" ("Anatom. Anzeiger," Vol. XVIII, 1901, Nos. 20-21); *H. v. Buttel-Reepen,* "Ueber die Dzierzon'sche Theorie" ("Bienenwirtschftl. Centralbl.," 1901, No. 1); "Der Abschluss der Freiburger Eiuntersuchungen" (Ibid., 1901, No. 19); "Die Parthenogenesis bei der Honigbiene" ("Natur und Schule," Vol.I, 1902, 4th issue); *P. Bachmetiew,* "Ein Versuch, die Frage ueber die Parthenogenese der Drohnen zu lœsen" ("Allgem. Zeitschr. f. Entom.," 1903, Nos. 2-3).

ing its cell and giving it different food.[1] Also in the case of termites, so we are informed by Grassi and Sandias,[2] the various methods of nursing the larvae, and especially the different salivary gland secretions of the nurses are of great importance in the differentiation of the castes of one and the same species. The same probably holds good with ants,[3] and, indeed, with far more variability than with honey-bees, although less than with termites. This is indicated by the numerous *intermediate forms* between the females and workers of ants.[4] Of course, wherever these appear, they are exceptional forms, yet none the less they throw some light on the origin of the *normal* differentiation into females and workers; for, their existence is most intelligible on the supposition, that the difference of caste is not predetermined in the egg, but that *it will depend on the nursing,* whether the fertilized egg will bring forth a winged, perfect female, a normal worker or perhaps some intermediate form.

Of course, the specific development peculiar to every ant-species is the necessary foundation for the differentiation of the normal castes and for the origin of certain abnormal, intermediate forms. Where there

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[1]) Cf. *N. Ludwig,* "Futtersaft oder thierische Veranlagung."— According to Planta's tables the food of queen-bees contains a far larger amount of fat. But according to *Ludwig* it is especially the different quality of the saliva, added by the bees to the nutrifying juice, which is of decisive importance.

[2]) "Costituzione e sviluppo della Società dei Termitidi" (Catania, 1893), pp. 75-106.

[3]) *Emery,* "Le Polymorphisme des fourmis et la castration alimentaire," Leyden, 1896 (Extr. du Compte rendu des Séances du 3me Congrès internat. de Zool., p. 395 ff.).

[4]) *Wasmann,* "Die ergatogynen Formen bei den Ameisen und ihre Erklaerung" ("Biolog. Centralbl.," 1895, Nos. 16 and 17).

is no possibility of developing into certain forms, there is, of course, no basis, no material for the exercise of the nursing instincts of the workers. From this it becomes clear, why fixed intermediate forms between females and workers occur with certain species, different forms with other species, whilst with others again there are none at all. But, within the limits of this natural disposition for further development, there remains to the ants a wide range for exercising their nursing instincts.

These intermediate forms between females and worker ants I have grouped into six classes, but here we are concerned with but one or two of them. In some of these *"ergatogyne" forms* it appears almost at a glance, how they came into existence, namely, whether the larva, reared up to a certain stage to be a worker, was later on cared for so as to become a female, or whether the opposite took place. In the first case the intermediate form makes the impression, that the worker-character had been developed to excess; in the second case, that the female character had been stunted; in the former the so-called worker-like (ergatoid) queens are the result, in the latter a kind of female-like workers, which I have named pseudo-females (pseudogynes). The former combine the vaulted thorax of females with the small and abdominal development of queens; the latter unite the vaulted thorax of females with the small and stunted abdomens of workers. Especially the latter form, the *pseudogynes*, are apparently best accounted for on the score of education rather than by a peculiar disposition inherent in the egg, from which they are

hatched.[1] I know some colonies of *Formica sanguinea,* near Exaten, in which these pseudogynes suddenly made their appearance, became more numerous in the course of the next few years, and gradually decreased later on, or disappeared entirely. One colony (No. 21) in 1895 reared every possible pseudogyne intermediate form between normal workers and normal queens! Since the queens which lay the eggs in these nests are unable to change at will the nature of their ovaries from year to year, but are always compelled to lay fertilized eggs, *capable of equal development,* the origin of those intermediate forms is probably due to changes in the *manner of nursing,* and to modifications in the very nursing instincts of the workers. This supposition is confirmed by the fact, *that in F. sanguinea there is a certain causal relation between the origin of pseudogynes and the education of the larvae of a genuine ant-guest, the beetle Lomechusa strumosa.* I have ascertained this mysterious connection by means of my statistics embracing 410 *sanguinea* colonies within a radius of several kilometers around Exaten; these statistics will be published later on in some scientific periodical.[2] Here it may suffice to mention, that the centres of propagation of the pseudogyne forms and of the *Lomechusas* are always together in the same

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[1]) See my recent publication, "Neue Bestaetigungen der *Lomechusa*-Pseudogynen Theorie" ("Verhandl. der Deutsch. Zool. Gesellsch.," 1902, pp. 98-108 and Pl. II), where this theory is extended also to North American ants. See below (the following section, p. 179 foll. and the plate opposite p. 181).

[2]) The beginning of those statistics dates back to 1895 ("Die ergatogynen Formen bei den Ameisen und ihre Erklaerung," "Biol. Centralbl.," 1895, Nos. 16 and 17).

or at least in neighboring nests. The number of colonies, in which I found Lomechusas (100), is more than three times as great as that of nests containing pseudogynes (33); these are the centers, from which the *Lomechusas* gradually spread to the neighboring nests, where by and by they cause the birth of pseudogynes. It is scarcely possible, that the presence of these beetles and of their larvae, which are fed by the workers, should have a modifying influence on the ovaries of the queens, but, probably they do so on the nursing instincts of the workers. My recent observations and experiments until 1904 have confirmed this solution of the interesting problem.

Some of the above mentioned intermediate ant-forms are useful for the preservation of the colony and the species, whilst others are more or less indifferent, and still others positively hurtful, being probably pathological deformities. The rearing of worker-like, wingless queens among the Amazon ants (*Polyergus rufescens*), for instance, is very appropriate, because their colonies are rather rare and far distant from one another. Therefore, the probability is very slight, that on their nuptial flight the winged sexes will meet with those of other colonies; and besides, this species has to encounter exceptional difficulties in founding new settlements by means of single fertilized females, since the Amazons are entirely dependent on the help of their slaves. The wingless queens, on the other hand, cannot go far from their nests; and after they have been impregnated by the winged males, some strolling slaves can easily find them in the neighborhood and bring them home again; hence it

is very suitable, that just *Polyergus* should so often rear ergatoid queens. Nor is this arrangement in any way due to the "intelligence" of the Amazons; for the education of their offspring is entirely committed to the care of their slaves (mostly *F. fusca*);[1] these slaves, however, have been robbed from colonies which do not rear ergatoid females, and neither reflection nor experience could have given them intellectual knowledge of the requirements peculiar to the nursing of *Polyergus*. Here animal intelligence is entirely powerless. If *F. fusca,* the slaves of the Amazons, rear the offspring of their masters in a way suited to the preservation of exactly this species, then we must admit, that the nursing instincts of the slaves are influenced and modified by the peculiar sensations caused by the *Polyergus*-nests.

But what shall we say of the rearing of pseudogynes with *F. sanguinea*? This combination of female and worker is decidedly injurious to the preservation both of the colonies and of the species. The pseudogynes are stunted beings, neither workers nor females, unfit to participate either in building the nest or in nursing the young,[2] in defending the colony or in propagating the race; in fine, they are *downright failures.* It is evident, that their origin is not due to the "individual intelligence of the ants"; for,

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[1]) Near Exaten, Holland, all Polyergus-nests, I met with, contained *F. fusca* as slaves; those which I found in Bohemia (Mariaschein), Austria (Vienna) and in Luxemburg, had *F. rufibarbis* as slave species. The ergatoid queens I met hitherto only in nests with *fusca*-slaves.

[2]) It happened only very seldom (among several hundred observations only five times), that, on the nest being exposed to the light, a pseudogyne seized and carried away an ant-larva, whilst workers are always wont to do so.

if they had but a spark of intelligence, sad experiences would have enlightened them long ago on the folly of this mistake. Nay more, if the pseudogynes owed their origin to the *normal* nursing instincts of ants, we should have to despair of the fitness of animal instinct and even of the wisdom of the Creator. What is the key to this mystery? It is the beetle *Lomechusa strumosa.* According to our hypothesis the rearing of the pseudogynes is an *aberration* of the breeding instinct of ants, caused by the continuous education of *Lomechusa*-larvae. In the economy of nature it is the duty of this beetle, to check the excessive increase of the ant-species, whose hospitality it enjoys. For this reason its larvae not only consume countless ant-eggs and ant-larvae,—the ants calmly looking on the while,—but by destroying the offspring of the ants, and by the care which the ants bestow on them, they cause *the degeneration of the normal nursing instincts of the workers,* resulting in the education of crippled pseudogynes.[1] To account for these facts on the score of "individual animal intelligence" would

[1]) These expositions will probably suffice also to refute an objection raised by *Dr. G. Adlerz,* who, misunderstanding my psychological explanation of the rearing of pseudogynes, says in the third part of his valuable "*Myrmecologiska studier*" (Stockholm, 1896), p. 51: "With regard to this Wasmann seems inclined to credit ants with an exaggerated power of reflection, which he otherwise is unwilling to do." Besides, the pathological degeneration of the breeding instinct explains, why the rearing of pseudogynes is still continued, even when colonies have been deprived of their *Lomechusas.* By the way, let me repeat a remark formerly made, that the *causal connection of pseudogynes* with the *Lomechusas* is not to be confounded with the *explanation* of this connection. The former seems to be firmly established by direct observation, the latter is still an hypothesis, but an hypothesis, strongly confirmed by recent experiments of myself and of Vichmeyer. See "Neue Bestaetigungen der *Lomechusa*-Pseudogynentheorie" ("Verhandlungen der Deutsch. Zool. Gesellsch.," 1902, p. 98 ff.).

involve us in endless and hopeless contradictions. They are explainable only from the standpoint of a higher, teleological consideration of nature, which does not presume to replace the wisdom of the Creator by the "intelligence of animals."

The phenomena in the nursing of ants mentioned above can be ascertained only by close, scientific observation. But some other features are known to every amateur in the study of ants, and do not escape even the most casual observer. The first thing that strikes our attention is the great attachment displayed by the workers for their charges. They carefully guard them against every disturbance, and at the risk of their own lives they exert all their strength in warding off hostile invaders. The whole colony is seized with frenzy, if an attempt is made to rob them of their larvae and pupae.[1] Merely thrust your stick into a hillock of wood-ants! At once there ensues a tumultuous uproar and masses of workers rush forth to rout the enemy. But if you happen upon a chamber filled with pupae and attempt to take away the cocoons, the fury of the ants reaches its climax. Like an army of raging furies they fall upon the assailant, viciously biting and ejecting their poison. Hundreds and thousands are crushed by the enemy, but other hundreds and thousands are eager to face the carnage. No lioness, no she-monkey ever defends her young with the heroism displayed by ants. Workers will rather

[1]) This is the case with species otherwise very peace-loving, e. g., with the large American leaf-cutting ants of the genus *Atta*. On opening a nest of *Atta sexdens* in Rio Frio, *Forel* even had an artery of his little finger pierced by a large-headed worker. See *Forel*, "Zur Fauna und Lebensweise der Ameisen im Columbischen Urwald" ("Mittheil. der Schweiz. Entom. Gesellsch.," Vol. IX, 9th issue, p. 407).

suffer their heads to be torn off, than yield to the enemy the pupae they carry in their jaws. And yet, it is not even for their *own* children, that they "sacrifice themselves so unselfishly;" their charges are but their foster-children. But that higher natural law, which has made preservation of the species the foremost instinctive commandment implanted in the animal soul, this natural law, I say, also constrains the worker-ants to risk life and limb in behalf of beings begotten by others. This commandment they observe faithfully, not led by any sense of duty or by noble forgetfulness of self, but by an irresistible, instinctive impulse implanted in them by Another, and to which they yield obedience, not intelligently or voluntarily, but urged on by a blind necessity of nature!

To credit animals with intelligence, to ascribe to them ever so faint a trace of intellectual knowledge of the purpose of their actions, will necessarily lead to extolling the self-sacrifice of the single workers for the welfare of the colony and especially for the young, as a high degree of quasi-human, nay of superhuman virtue. And in fact, L. Buechner, E. Haeckel, Th. Eimer, O. Zacharias and other modern animal psychologists have actually ventured such assertions.[1] Of course, their only commendation is their boldness, but it is a boldness leading to the greatest absurdities.

What is it then, that impels the ants to such heroic devotedness and self-sacrifice for the offspring of their colony? Is it perhaps "motherly love"? No; for the workers are but the sisters or aunts of their

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[1]) *Wasmann*, "Die zusammengesetzten Nester und gemischten Kolonien der Ameisen," pp. 190 and 191.

charges, since under ordinary circumstances the eggs are laid only by the impregnated females. Their affection, therefore, as sisters or aunts is the psychic impulse of their nursing instinct. According to modern animal psychology, which ascribes to animals besides their instinct at least a modicum of genuine intelligence, it cannot be doubted, that the worker-ants fulfill their duties as sisters or aunts "very knowingly," that they are aware of the importance of the work allotted to them in their social economy, and that they apply themselves to nursing the offspring of another with the consciousness of doing their duty. But to what degree will the love of the workers for the young be advanced, if to their affection as sister or aunt there is added *"motherly love"* in the full sense of the term? Must we not expect that the love of the workers for their *own* young should attain to an exalted, an unutterable degree of tenderness? For, in the whole creation no love is stronger than that of a mother.

Indeed, our expectations would be justified, if ants were endowed with intelligence and self-consciousness. But what do we find in reality? *The workers generally devour most of the eggs, which they have laid themselves.*[1] Is this the climax of noble, self-sacrificing motherly love? Or shall we call these workers abominable cannibals regardless of duty? The psychology of Brehm and others of that ilk may decide this question. In our opinion, however, such facts ought to lead reasonable people to perceive the obvious contradictions, in which all the talk about "animal

[1]) See my observations in "Biolog. Centralbl.," XI, 1891, p. 21 ff.

intelligence" and "animal ethics" is hopelessly involved.

The nursing instinct of ants with all its "devotedness and unselfishness," is therefore nothing else than a *purely* instinctive impulse guided and determined in its operations only by sensitive impressions and not by intellectual concepts. Under normal circumstances this instinctive impulse is appropriately regulated, and manifests itself as the product of "self-sacrificing sisterly love." But, if the abnormal irritation of the nervous system of the ants, caused by parthenogenesis, has disturbed the normal sphere of sensitive impressions, then sisterly love is not changed into motherly love, but into "barbarous, unfeeling cannibalism"!

Modern animal psychology evidently toys in a rather frivolous manner with the term "motherly love," by applying it to the nursing instincts found among animals. Nor can the plea be advanced, that with higher animals matters are quite different than with ants; for, we have proved above, that the nursing instincts of ants far surpass in perfection those of birds and mammals, not only by their quasi-intelligent self-determination in the method of education, but also by the great unselfishness manifested in nourishing and defending their young. If there should be any difference at all, it is in this, that in the care of their offspring the higher animals betray *far less* "intelligence" and *far less* "individual liberty," than is found in ants. Moreover, it is a well-known fact, that domestic pigs not seldom devour some of their litter; yet pigs are "higher animals." In such cases, however, the sow sins as little against good morals,

as worker-ants do by devouring their own eggs; for, morality presupposes reason and free-will, reflection and consciousness of duty, all of which are wanting *throughout the animal kingdom,* being the exclusive privilege of man.

That animals in caring for their young are not led by reason, but only by sensitive emotions and representations, becomes evident especially from the *phenomena of adoption* in the animal kingdom. Therefore these shall form the subject of the following section.

3. *Adoption Instincts in the Animal Kingdom.*

The tendency to adopt the offspring of strangers is shown by all those animals which, to preserve their species, are forced to bestow great care on their own progeny. This tendency is found among ants not only with regard to the eggs, larvae and pupae of other colonies of their own species or of allied species, but also with regard to members of altogether different orders of insects, living in their communities. These adoption instincts are responsible for the mixed colonies of slave-making ants, the robbed pupae of the slave-species being nursed as carefully as others, either by the masters or by the slaves already present in the nest. To the same instinct of adoption must be referred the care bestowed by the ants on their genuine guests or other nest-mates belonging to different orders of insects, but above all, the solicitude with which they rear the larvae of certain beetles (*Lomechusa, Atemeles, Xenodusa*) and the eggs of several kinds of plantlice. The adjoining illustration

shows the beetle *Lomechusa strumosa* so often referred to, and one of its larvae, magnified to four times their natural size.

Fig. 4.
Lomechusa strumosa F.
(Magnified.)

Fig. 5.
Fullgrown larva of *Lomechusa strumosa.* (Magnified.)

The same adoption instinct occurs also with birds, although not so seemingly intelligent as with ants. The best-known example is the hen, that readily hatches eggs of other hens, ducks, geese, turkeys, etc., and extends to all her adopted children the same "motherly care," she would show to her own chicks. G. Romanes[1] succeeded even in making a hen the foster-mother of some young ferrets, which he had substituted for the artificial eggs, on which she was hatching. The numerous species of birds, which tend the young cuckoos, follow the same line of conduct, the only difference being, that they lavish still greater care on these changelings, because they open their mouths wider in crying for food than their own nestlings. The adoption instinct, finally, is met with among mammals, the most blood-thirsty carnivores not excepted. Though it is a fable, that ancient Rome

[1]) "Mental Development in the Animal Kingdom."

owed its origin to the adoption instinct of a she-wolf that gave suck to Romulus and Remus, yet similar facts are fully authenticated; for instance, that suckling cats adopt young rabbits and squirrels.[1] Especially among apes this instinct is quite prominent, but much more characteristically unreasonable than with any other animal. Of course, for a certain kind of modern animal-psychology, which is accustomed to the most superficial observation, such occurrences are noble manifestations of human compassion, and of an abundance of "motherly tenderness" lavished on the offspring of strangers. But accurate, scientific observation and critical investigation prove the very contrary, namely, that throughout the animal kingdom the nursing instinct is but a *sensual impulse,* unaccompanied by individual intelligence or individual morality.

If a hen calmly continues trying to hatch pieces of limestone or links of iron chains put in place of her eggs, she can hardly be said to be actuated by "motherly love." Animals merely endeavor to satisfy their instinctive breeding impulse; the higher purposes of their action are altogether unknown to them. William of Reichenau relates that a bitch, being robbed of her pups, fetched an old pair of slippers and tried to suckle them.[2] Whether she thereby intended to allay her pangs of conscience as to the fulfillment of her "maternal duties," animal psychologists à la Brehm will be better able to decide than we, to whom such facts merely prove, that the nursing instinct in

[1]) Cf. *W. Herd,* in "Scottish Naturalist," 1872, p. 155.
[2]) Cf. "Kosmos," 4th year, VII (1880), p. 217.

animals is a sensual impulse, not guided by reason and reflection.

This organico-sensitive nature of the nursing instinct also explains, why it often extends to the helpless offspring of other species, whose instinctive behavior is somewhat similar to that of the animal's own progeny. The sense-perception of these helpless beings stimulates the nursing instinct of the old ones, and therefore they "adopt" the young ones of strangers. The smell of the larvae of *Lomechusa strumosa* is especially attractive to the sanguine slave-makers;[1] besides these larvae instinctively mimic the attitudes and behavior of the ant-larvae, and although they possess six feet, they do not make use of them, but conduct themselves like helpless ant-larvae. For these reasons they enjoy the most careful attention on the part of their hosts. And as these beetle-larvae, when fed by the ants, grow much faster than the ant-larvae, they impress the instinctive nursing impulse of the ants far more favorably than the latter, and hence are the objects of "greater tenderness." At any disturbance of the nest the workers first care for their "adopted children" and bring them to a place of safety, before they attend to their own offspring; yea, they even neglect the rearing of the latter, their only care

[1]) That the ants do not confound those coleopterous larvae with their own on account of their shape and color, I ascertained, in May, 1897, by experiments with larvae of *Anthonomus pomorum*, which are far more similar to ant-larvae than those of *Lomechusa*. The *Anthonomus*-larvae were instantly seized as prey and torn to pieces by the *sanguineas* of my observation nest. On the whole, it must not be imagined that the *Lomechusa*-larvae make the *same impression* as their own on the sensitive perception of the ants; the impression is at most similar, but more agreeable, which probably explains why the ants prefer the adopted larvae to their own.

being their *Lomechusa*-larvae, so dear to them on account of their quicker growth and their better appetite. It does not affect the ants in the least, that the *Lomechusa*-larvae again and again devour the eggs and young larvae of the ant colony by the wholesale; on the contrary, they even carry these changelings to the clumps of eggs and larvae to facilitate their work of destruction. Unless a superior Wisdom had provided that the ants themselves, by their stupid affection, prevent the excessive increase of the *Lomechusa* population, the number of these guests would become so large as to destroy all the *sanguinea*-colonies. But there is no danger of any such calamity; for, the ants deal with the *Lomechusa*-larvae during their pupation just as they do with their own, imbedding them carefully in a vault of earth. After a short time, the ant-larvae having meanwhile spun their cocoons, are again removed from the earth. This latter measure applied to the *Lomechusa*-larvae proves fatal to them. The larvae of these beetles do not spin a solid cocoon, but only an extremely flimsy, silken web, which tears as soon as they are unearthed; soon after the *Lomechusa*-larvae are again carefully imbedded at some other place, then they are taken out again, carried about, again imbedded, until at length they become dry and perish. In this manner the folly of the ants causes most of the *Lomechusa*-larvae to die before they are changed into pupae; and even those, which have fortunately entered the state of a pupa, are often unearthed by the ants and devoured, —perhaps from an excess of affection? According to my long continued observations on the development

of *Lomechusa strumosa* in normal *sanguinea*-colonies only those larvae escape destruction, which, after having been imbedded in their little cave, are *forgotten* by the ants; all the rest are hopelessly doomed; of 100 larvae, therefore, at most about 10 reach the stage of imago, sometimes scarcely one. For instance in the observation nest illustrated on p. 23 in May, 1896, about 150 *Lomechusa*-larvae, the offspring of 10 *Lomechusas,* were reared under the most favorable conditions both of nutrition and temperature; from these 150 larvae I obtained—*one single Lomechusa!*

For thousands of years and in thousands of normal colonies *F. sanguinea* year after year repeat the same senseless performance: first, with the greatest devotedness they nurse the *Lomechusa*-larvae, even allowing their own offspring to be devoured by them; then, their stupid affection does not allow them to leave the larvae in peace during the time of pupation, and finally they devour the pupae. They cannot see that during their pupation *Lomechusa*-larvae are to be treated *differently* from those of ants; but this is their salvation; for otherwise their care of the *Lomechusas* would long ago have brought about the ruin of their own race. One and the same superior Wisdom has designed, that on the one hand the increase of the ants be checked by their inconsiderate love for *Lomechusa strumosa* and for their larvae, and that on the other hand the spread of this beetle be kept within limits by the very same unreasonable affection of the ants. By these means so gentle and yet so effective, *Divine Wisdom* is able to maintain the equilibrium in nature. In the face of such phenomena, the defenders

of animal reason and animal ethics stand utterly bewildered.

We have seen so far, how the *Lomechusa*-larvae are treated in *normal sanguinea*-colonies, in which the education of *Lomechusas* dates but one or two years back. According to my observations during the last years, the case is, however, different in colonies, where the influence of the parasitic larvae of that beetle has caused the appearance of those crippled, intermediate forms between females and workers, which we have called *pseudogynes*. For the reason mentioned above, only a few *Lomechusas* are developed, as a rule, in the normal colonies, whereas in colonies containing pseudogynes, many more of the beetles pass their pupation successfully, because the pupae generally remain undisturbed. This accounts for the fact, that the *sanguinea*-colonies containing pseudogynes are the *centers* from which the rapidly multiplying *Lomechusa* infests also the neighboring nests. One instance may be mentioned here. Colony No. 191 of my statistical map in the middle of May, 1898, had from 2 to 3% of pseudogynes; in August, however, the number of pseudogynes newly developed during summer had risen to 30%! In order to ascertain, how many beetles had been reared in this colony in 1898, I dug up the nest at the end of September and found among the ants 116 *Lomechusas*[1] snugly ensconced in their winter-

[1]) From this number the 30 *Lomechusas* were taken, which I put in my *sanguinea* nest at home and the greater part of which were again driven out by the ants (see p. 59). This surprising conduct is somewhat accounted for by the fact that the colony of my observation nest belonged to the *normally* developed class, and not to such as *contained pseudogynes*.

quarters. The rapid increase of pseudogynes in that colony, therefore, was in proportion to the number of beetle-larvae which had successfully developed in the same nest that year.

It is, therefore, necessary to assume, that in *sanguinea* colonies the frequent rearing of *Lomechusa*-larvae gradually *modifies the normal nursing instinct of the ants.* This modification is manifested partly by the production of the crippled pseudogynes, partly by the more appropriate treatment of the *Lomechusa*-larvae which, after having been imbedded in their cradles, remain undisturbed. Ants, therefore, gradually learn to modify their nursing instinct. Is not this a proof of intelligence? True, their sensitive cognition guiding their instinctive activities may furnish the immediate occasion for that two-fold modification. But we have proved in a former essay, in discussing the different forms of learning,[1] that not every modification of the hereditary instinct, occasioned by sense-experiences, is due to intelligence, but only that, which manifests a knowledge of the appropriateness of a given action. If ants were gifted with intelligence, they could not help understanding, that by improving their treatment of the *Lomechusa*-larvae, they cause their colony but to perish the sooner, just as they condemn it to utter destruction by rearing pseudogynes. The latter modification of the nursing instinct, which leads to the rearing of cripples, can only be a pathological symptom, pointing to a morbid disturbance of the normal, organic condition of that

[1]) "Die psychischen Faehigkeiten der Ameisen," p. 111; "Instinct and Intelligence in the Animal Kingdom," Chap. 8.

Fig. 1.

Form. sanguinea Ltr., subsp. *rubicunda Em.* Normal dealated queen from Prairie du Chien, Wisconsin, U. S. A.

1

Fig. 2.

Form. sanguinea Ltr., subsp. *rubicunda Em.* Normal worker, from the same nest.

2

3

Fig. 3.

Formica sanguinea Ltr., subsp. *rubicunda Em.* Pseudogyne from the same nest.

4

Fig. 4.

Xenodusa cava Lec., whose larval education caused the rearing of Pseudogynes in the same colony of ants.

(All figures magnified to seven times their natural size.)

instinct. Hence, the improved education of the *Lomechusa*-larvae which is invariably attended by an impaired education of their own larvae, is not owing to intelligence on the part of *Formica sanguinea,* but to a disturbance of their normal, instinctive disposition, occasioned by nursing the strangers.

What we have said here of the rearing of our European *Lomechusa strumosa* by the *sanguinea,* has its exact counterpart in North America, where the larvae of *Xenodusa cava,* a species nearly allied to *Lomechusa,* are educated by the North American race of *F. sanguinea,* which Emery has named *F. rubicunda.* Rev. H. Muckermann, S. J., of Prairie du Chien (Wisconsin) has succeeded in finding also the pseudogynous ant-form in an infested nest of *F. rubicunda.* In the *Verhandlungen der Deutschen Zoologischen Gesellschaft* (1902 p. 98-108) I have given an account of these observations,[1] which are illustrated on Plate II of the "Verhandlungen." We give here a copy of this plate, to show more clearly what pseudogynes (fig. 3) are, and how they differ from the normal queen (fig. 2) and the normal worker (fig. 1) of the same ant-species. The malefactor, *Xenodusa cava,* is photographed in fig. 4.

To be sure, at the first glance the care bestowed by ants on other animal species, their guests or nest-mates, often looks like intelligence. This explains to a certain extent, why modern animal psychologists attempted to utilize these occurrences as arguments for the great intelligence of ants. This attempt was

[1]) Of late Father Muckermann himself has published an illustrated account of his discovery in the "Entomological News," (Philadelphia), December, 1904.

made, e. g., by William Marshall in his "Leben und Treiben der Ameisen" (p. 102), where he speaks of the care given by ants to the eggs of plantlice. Several ant-species of the genus *Lasius* collect the eggs of certain Aphides in their nests. Being carefully protected during winter, the young aphides in spring are carried to the plants on which they find their food. Thence Marshall infers, that the ants tend the eggs with the *intelligent purpose* of enjoying later on the sweet secretions of the aphides. "This is surely a very strange phenomenon," he says, "which proves perhaps better than anything else the *high degree of intelligence* attained by ants. We must credit them with a *considerable power of observation*, and we must own, that they have *studied*, to a certain degree, the habits of their domesticated animals," etc. Yet this bold conclusion is entirely unfounded. How does Marshall know, that the ants gather the eggs of the aphides with the intelligent purpose of rearing aphides? That there is some connection between the eggs of the aphides and the aphides themselves is, indeed, for many ants a subject of sensitive knowledge and experience; but it is unwarrantable to mistake this process of instinctive association for intelligence proper. Even if ants in reality tended the eggs of aphides only on account of a combination of their sensitive experiences, this would be as yet no proof of their intelligence, but merely of their memory. In reality, however, the case is different. Take a few newly developed workers of a *Lasius* nest and unite them to form an autodidactic colony, restricted to its innate instincts without a shadow of experimental

knowledge as to the development of aphides. Entrust them with eggs of those aphis-species, which their congeners are wont to rear and to nurse. They will treat them as though they had previously "studied" the habits of these aphides! Hence the fondness of certain ant-species for the eggs of aphides is a *merely instinctive impulse,* which, of course, can be strengthened by sensitive experience. It was rather rash for Mr. Marshall to proclaim it boldly as *"a faculty of taking the future into account."* Alfred Espinas was far more correct in calling the aphis-nursing of ants an "intelligence non réfléchie," i. e., merely analogous to human reason, having but a faint similarity to intelligence proper, the difference being not merely of degree but of kind.[1] This *analogum rationis* is simply an instinctive association of representations, assisted by sensitive experience.

In spite of the perfection attained in their nursing of plantlice, the *Lasius* species are far inferior to the *Formica* species in what modern animal psychology erroneously styles intelligence, viz: in the ability to profit for the future by past experiences. It will be interesting, therefore, to examine, in how far the latter ant-species, in taking care of their offspring, "consciously foresee the future."

Whenever care is taken of the young, then also the future is *instinctively* taken into account, above all in the rearing of the female ant-larvae; for it depends entirely on modifications in the nursing, whether the fertilized egg will produce a female proper or a worker. But only uncritical popular

1) "Sociétés animales" (2d ed.), pp. 157, 188, etc.

psychology is able to confuse *instinctive intention* and *instinctive foresight* with *intelligent intention* and *intelligent foresight.* This is made evident by the following facts. The beetles of the genus *Atemeles* have their larvae reared by certain *Formica*-species, *Atemeles emarginatus* by *F. fusca, Atemeles paradoxus* by *F. rufibarbis, Atemeles pubicollis* by *F. rufa, Atemeles pratensoides* by *F. pratensis.* The young *Atemeles* having successfully reached their full development, either quit the *Formica* nests or are driven out of them. They then move over to *Myrmica rubra*[1] and spend the greater part of their lives in the nests of these ants, by whom they are licked and fed. Only in spring, in the mating season, they return to their respective *Formica* species, where they allow their offspring to be reared at the expense of the ant-larvae. For whom, then, are these *Formica* species nursing the young *Atemeles*? Not for themselves, but for the *Myrmica* species. The only consequence of their adopting the *Atemeles*-larvae is the immense damage inflicted on their own eggs and larvae by these voracious changelings. Where now is "the faculty of intelligently taking the future into account," with which Marshall credits his ants? For thousands of years the *Formica* again and again have had the sad experience, that the pains bestowed on these beetle-larvae are but "love's labor lost."[2] I believe that if

[1]) This older collective name comprises *Myrmica scarbrinodis, laevinodis, ruginodis, sulcinodis* and *rugulosa.*

[2]) The same applies to the education of the larvae of the North American *Xenodusa* in the nests of *Formica* species; for, the *Xenodusa* are found as fullgrown beetles with other ants, especially of the genus *Camponotus.*

Mr. Marshall had not been ignorant of the development of these myrmecophilous beetles, he would scarcely have extolled the great intelligence of ants.

Lomechusa strumosa spends her whole life with *F. sanguinea* which, no doubt, is the "most intelligent" of European ants. She remains with her hosts after having attained the state of imago, and even, as a general rule, abides in the same nest, in which she was reared. In this case, therefore, the ants really derive some profit from rearing the *Lomechusa*-larvae. They not only have the pleasure of gratifying their nursing instincts by the rapid growth of these adopted children, but also later on they enjoy an agreeable, narcotic stimulant obtained by licking the yellow hair-tufts of the beetle. But if the ants had the faintest trace of intelligence, would they really be foolish enough to rear the *Lomechusa*-larvae merely for the sake of this sensual gratification? They experience again and again, that these changelings are their worst enemies, that they destroy their brood and moreover cause the birth of the merest cripples, namely the pseudogyne workers. Hence ants ought to have perceived long ago, that by rearing the *Lomechusa*-larvae they are guilty of a folly little short of suicide. But alas, the very contrary is the case. The longer *Lomechusa*-rearing has been going on in a given *sanguinea*-colony—which time can be ascertained by the increasing number of pseudogynes,—the more care is bestowed on these beetles; and the percentage of beetle-larvae, which, after being imbedded in the earth, are left undisturbed, is continually increasing. The experiences made only serve to entangle the ants

more and more in the toils of their treacherous guests. In the face of such facts "animal intelligence" is altogether untenable. On the other hand, these facts furnish a new argument proving the correctness of our explanation of the psychic activities of animals.

Birds which nurse the unfledged cuckoos, do not behave a whit more reasonably than the ants with regard to their *Lomechusa*-larvae. Because the young cuckoo opens its bill wider, makes more noise and wiggles its stumpy wings more energetically, its "foster-parents" feed it with special devotedness, and rather suffer their own young to starve. Moreover they calmly look on, whilst the young cuckoo pushes their own offspring over the edge of the nest to make them fall to the ground; indeed it has been observed, that the foster-parents assist in this work.[1] Among birds, too, the nursing and adopting instincts are due to the very same laws of sensitive life as in ants. There is no discrimination between their own offspring and that of others, no idea of "consanguinity," of "parents" or "children," but everywhere we witness the same unreasoning dependence on instinctive sense-impressions, the appropriateness of which for the welfare of their own or of strange species escapes the sensitive knowledge of the animal.

This is manifest also in the care bestowed on their young by the highest mammals, the apes. Just as within the same species of ants eggs, larvae, and pupae are a kind of international property, and are therefore received and nursed also by other colonies; as the eggs of eider ducks, of hens and other birds

[1]) "Westfalens Thierleben," II, 22.

have the same international character, extending even to the rearing of the young developed therefrom; as in many ants and birds the instinct of adoption, which is founded on the external resemblance between the nurslings of strangers and their own, is now and then extended to entirely different species (*Lomechusa,* cuckoo): so there is in apes a similar instinct owing to the same psychological causes, which proves to evidence the lack of intelligence in animals. "It is a well-known fact," as the third ed. of *Brehm's* Tierleben (p. 52) has it, "that apes, without much ado, adopt the children of any other species, protect them with the utmost tenderness, and can scarcely be separated from their dead bodies. When our shepherd-dog Trina would present us again with young puppies swarming with fleas, we used to put them into a cage of marmosets. There they were heartily welcomed, cleaned and fondled with care and tenderness, whilst from without the old dog was watching with a knowing look (*sic*). But as soon as we deprived them of their nurslings, the monkeys would set up a pitiable screaming: they had distributed the pups among their number and evidently intended (*sic*) to keep them." The anthropomorphism, with which modern fanatics in the matter of animal intelligence try to varnish over the true character of these adoption phenomena, must be mercilessly exposed by genuine, critical psychology. We wish to picture the psychic life of the animals such as it is in itself, and not as it exists in the imagination of would-be psychologists.

That the inclination of apes to adopt the offspring of other apes, of dogs, cats, rabbits, Guinea-pigs, and

even of man is an *entirely instinctive* impulse devoid of intelligent reflection, is so evident to logical minds and so plainly expressed in the facts, that further proof seems superfluous. Since with apes the two sexes differ far less in psychic endowments than with ants, it can hardly be surprising, that not only the females but also the males have an instinctive nursing inclination, and try to gratify it by nursing any young animal. But how do they do it, especially if the young ones belong to another species? Alfred Brehm says,[1] "Here the ape often appears to be an *inexplicable puzzle*. He nurses his adopted favorite to the full extent of his power, hugs him, cleans him, continually keeps an eye on him, *but generally does not supply him with any food*. Without pangs of conscience (*sic*), he keeps for himself the food destined for his nursling, and even carefully keeps him away from the pot, whilst he himself is eating. This I have observed with baboons, who had picked up young dogs or cats as their foster-children."

Is this really an *"inexplicable puzzle"*? Only for those who are *unwilling* to understand the correct solution, because they are blinded by their monomania on animal intelligence. The solution of the puzzle is as clear as day-light. The instincts both of nursing and of eating are *purely sensitive inclinations,* unattended by reason and reflection. The faculties of sensitive cognition and appetite are so appropriately disposed in animals, that with regard to their own offspring the nursing instinct is stronger than hunger, but only so long as the young of that species, under

[1]) Ibidem, p. 51.

normal circumstances, require nursing. Encaged she-apes often dispute every bite with their offspring, although they themselves have enough to eat; yea, they would even allow their "darling children" to starve, unless they were prevented by force, or unless the young possessed the strength and agility to get at the food in spite of the envy and greediness of their "dear mamma."

Critical psychology cannot but regard these phenomena as evident proofs, that even the highest animals are *unreasonable beings*, whose actions are guided *only by instinctive impulses*. Under normal conditions, the nursing instinct which serves to preserve the species, is, in animals, with regard to their own young, stronger than hunger, which provides for the preservation of the individual; the higher law of preserving the species demands so. Hence, in the beginning the mother-ape suckles and feeds her young with unrivalled "unselfishness," whereas later on she grudges it every bite; hence apes hug and nurse the young of strangers with every sign of affection, whilst at the same time they deny them food and cruelly allow them to starve; hence the worker-ants nurse with motherly tenderness the eggs not laid by themselves, whereas for the most part they devour the eggs, which they have laid by way of parthenogenesis. Their natural duties being those of nurses and not of mothers, these loving aunts then become cannibals and monsters of cruelty, because their instinct of eating is subordinated to that of nursing not by intelligence or consciousness of duty, but by the appropriate disposition of their sensitive appetite.

Let us briefly sum up the results of our discussion on the nursing instinct of animals. In this respect all animals obey the same psychological laws. Everywhere the inclination of nursing and rearing the young proves to be a *sensitive instinct,* entirely different from, and even *excluding,* individual reflection and consciousness of duty. This is the case both in the highest mammals and in ants; for the latter even far surpass the highest mammals by their quasi-intelligent freedom of choice in rearing the different castes, and by an attachment to their charges verging on heroic unselfishness. With all animals the care of the young is directed exclusively by sensitive impulses and perceptions, which, under normal circumstances, are suitably regulated both for preserving their own species and for maintaining the equilibrium between different species. Yet this appropriate correlation is far beyond the ken of the animal; hence, in the nursing of animals there is no question of any "consciousness of duty." Man alone by virtue of his intellect perceives the relations of consanguinity and the connections resulting therefrom; he alone has an *intellectual notion* of "parents" and "children"; only with him can there be question of the *moral duties* of parents toward their children. True, also in man motherly love is founded on a *sensitive instinct;* but, at the same time, it is *spiritual,* because the mother knows that she is the mother of this child, and because this knowledge with the resultant consciousness of the duty of attending to the welfare of the child, lasts for life. In man the love of parents toward their children and the care they bestow on them rises far above

the sphere of sensitive instinct into the province of spirituality and morality: and because the love of a mother is a *rational* love, *conscious of duty,* therefore it is the highest and noblest love existing in nature. To ascribe such motherly love to animals, as do modern psychologists, is nonsense, scientifically speaking, and morally speaking it is a degradation of human dignity.

CONCLUSION.

NOT to exceed the limits of this publication, we must refrain from pointing out other parallels existing between the psychic life of ants and that of the other animals. In particular, the extremely various ways of gaining a living, prevalent in ant-communities, would furnish plenty of material. But in this essay we had to confine ourselves to a few stray remarks on that subject (p. 38). What we have dilated upon may suffice, however, to furnish a positive and reliable answer to the question, with which we introduced our essay, namely: *Are animals endowed with instinct only, or also with intelligence?*

We have already proved in a former publication (Instinct and Intelligence in the Animal Kingdom), of which the present study is a confirmation, that modern animal psychology influenced by so-called popular psychology, has inverted and confused the notions of sensitive cognition and of intelligence. That which is popularly styled animal intelligence, in as far as it is based on real facts and not on fables and anecdotes, is nothing but the faculty of the animals of forming complex representations of their sensitive experiences and of acting appropriately in accordance with them. But this power as well as the immediate instinctive cognition is due to the innate laws of associations of sensitive representations and affections; hence it belongs to the sphere of *sensitive*

instinct, not to spiritual intelligence. By a critical, psychological analysis we were led to define *instinct* as the *appropriate disposition of the sensitive powers of cognition and appetite.* Hence, any action resulting therefrom must be called *instinctive*, whether experience is concerned in it or not. But only those actions can be called *intelligent*, which presuppose the *understanding* of the relations existing between the sensitive representations, and which cannot be explained by any other supposition. *Intelligence,* therefore, exclusively signifies the power *to act with deliberation and self-consciousness.* Only this power can be called a *spiritual faculty;* the sensitive power of representation and memory cannot be so called, notwithstanding the efforts of modern animal psychologists. The pretended *"spiritual life"* of animals, about which popular psychology continues to make such ado, is based on the confusion between sensitive and spiritual faculties.

Modern animal psychology splits up the psychic life of animals into two different factors, styled *instinct* and *intelligence,* between which an artificial contrast is established. Our explanation of the psychic life of animals is *more consistent* and *more natural.* What is erroneously termed animal intelligence, we have traced to the *same* source as the instinctive actions strictly so called, namely, *to the suitable hereditary disposition of the sensitive cognition and appetite,* which we call *"instinct;"* for, this disposition has a twofold aspect, one automatic, the other plastic. It is *automatic*, inasmuch as it is determined by heredity, and therefore induces the animal to per-

form certain actions, which are independent of individual experience and are more or less the same in all individuals of a given species. It is *plastic*, inasmuch as within this limited sphere, the powers of cognition and appetite in the animal are given more or less play for variously modifying their activities. The narrower the limits within which they are confined, the more automatically their instinct will cause them to act; the wider those limits, the more plastic their instinct. Both elements, automatism and plasticity, are found in different proportions with *all* animals from the highest to the lowest. In the lower orders automatism, as a general rule, largely prevails, whereas in the higher vertebrates plasticity is, on the average, more predominant. Ants, too, more than dogs and apes, are bound by hereditary laws to the performance of certain activities. The varying influence, which individual sensation brings to bear upon the performance of hereditary instincts, is greater and more variable in the latter than in the former, and in this respect the psychic life of ants is more like "automatism" than that of mammals. But, on the other hand, the plasticity of the instinct is, also in ants, often highly developed, and not rarely it is manifested in a more quasi-intelligent form, than even in the highest vertebrates.

In the present essay we have reviewed a number of the most prominent phenomena of the psychic life of animals, and everywhere we found, that, what modern animal psychology styles animal intelligence, is met with also in ants and in many cases, in fact, in a higher degree than with the highest mammals. In

the community-life of ants, which with suitable co-operation for the welfare of the colony combines a manifold independence of action on the part of the single workers, in their mutual communications and mutual services, in their wars, in their slave-making expeditions and their confederations, in their nest construction and in the manifold application of their building skill to various changes of circumstances, finally, in their breeding and nursing, embracing various methods of education left to the choice of the workers and manifesting, at the same time, the highest degree of "self-sacrificing attachment" to their helpless young ones: in all these points combined we must rightly consider the life of ants as *the climax of development in instinctive life throughout the animal kingdom.* As regards the perfection of the nervous system and of the sense-organs, the higher mammals are indeed far closer to man, than the ants; but as regards the quasi-intelligent actuation of animal instinct under the influence of sense-perceptions and experiences for the various purposes of community-life, ants no doubt approach nearer to man than even the anthropoid apes. Indeed, neither of them possesses *intelligence proper,* that is to say, the power of acting with deliberation and self-consciousness, of inventing new means for attaining various purposes and thus making progress in civilization. Still, the chasm between the psychic life of animals and that of man, is, in many respects, *wider* between ape and man, than between ant and man.

Of course, the results of our study are very different from, and indeed altogether contrary to, the

aprioristic postulates of modern evolutionism,[1] according to which man is nothing but the highest brute,

[1] We cannot enter here on the general question of the development of instincts. Cf. for this purpose my former publications: "Die Entstehung der Instincte nach Darwin" ("Stimmen aus Maria-Laach," XXVIII, 333), "Die Entwicklung der Instincte in der Urwelt" (ibid. XXVIII, 481; XXIX, 248, 383); "Zur Entwicklungsgeschichte der Ameisengesellschaften" ("Die zusammengesetzten Nester und gemischten Kolonien der Ameisen," III section, 2 Chap.).

As to the explanation of the genuine guest-relationship (symphily) by the Darwinian theory of evolution cf. "Zur Entwicklung der Instincte" ("Verhandlgn. der Zoolog. Botan. Gesellsch.," Wien, 1897, 3d issue, pp. 168-183). Of late *Dr. K. Escherich* has tried to solve the contradiction, which we proved to exist between the facts of symphily and the principles of natural selection ("Zur Anatomie und Biologie von *Paussus turcicus*, Zugleich ein Beitrag zur Kenntnis der Myrmekophilie," in "Zoolog. Jahrbuecher" Abth. fuer Systematik, XII, 1898, 27-70). He insists that symphily is not a separate instinct totally different from the breeding instinct of ants, but that the two are in causal relation to each other. We formerly (see the *first* German ed. of present essay, p. 107 below, and p. 108 above) pointed out the same. Yet Escherich is wrong in believing that natural selection has been unable to prevent the development of symphily in spite of the damage done by it to the ants, because symphily is so closely connected with the breeding instinct. Natural selection must counteract not only the development of an entirely new instinct which proves injurious to the possessor, but also the extension to injurious objects of an already existing useful instinct; hence selection was just as little allowed to let the breeding instinct of ants extend its activity to *Lomechusa*, *Atemeles*, *Paussus* and other noxious objects, as it was allowed to let the feeding instinct of animals extend its activity to palatable but poisonous herbs or to nutritious plants covered with parasites. (Cf. "Die psychischen Fachigkeiten der Ameisen," 1899, p. 124.) To this Escherich again objected (in "Zool. Centralbl.," 1899, No. 1, p. 17), that many sheep are killed by feeding on plants covered by "cercaries" (*i. e.*, the capsulate form of undeveloped trematodes). But what would Mr. Escherich say to the following, if within the whole species of sheep, or within a certain race of them, there should develop a *special liking* for feeding on plants covered by those parasites? Would not such a phenomenon evidently contradict the theory of natural selection? But this is exactly the case with the rearing of *Lomechusas* by the sanguine slave-makers. Therefore Escherich's objections but confirm the truth of our assertion: *The fact that ants by nursing their guests rear their greatest enemies, is equally incompatible with the principles of natural selection and with the principles of modern animal psychology.*

and human society but a gradual evolution from that of the higher mammals. But scientific research cannot be hampered by such aprioristic theories; if they are incompatible with facts, they are to be abandoned. It is an undeniable fact, that between the soul of man and that of the brute there yawns a chasm, which cannot be bridged over by any evolutionistic speculation.[1] *Man is, as a matter of fact, the only being in the visible universe, who is gifted with reason, with a spiritual soul, and with morality.* On account of the essential difference between sensitive and spiritual life, it is simply impossible, that in the course of nature an animal should ever develop into man. True, we can daily witness, how from instinctive sensations children gradually arrive at spiritual reasoning; but this development is possible only because from the outset the soul of the child is a *sensitivo-spiritual* soul. The development of its spiritual faculties must be preceded by sensitive instincts, because these furnish the foundation and the materials for the spiritual faculties. The animal, however, which *never* manifests spiritual faculties, cannot be credited with anything beyond a *sensitive soul,* which is essentially different from the *sensitivo-spiritual* soul of man, and which makes the animal, be it ape or ant, a being devoid of reason, and belonging to a lower order!

Hence, so-called popular animal psychology, which denies the essential difference between the human spirit and the animal soul, and which appeals in favor

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[1]) Even evolutionists like *Wallace* have well understood this, and therefore they protest *against* applying Darwinism to the psychic part of man. Cf. *Wallace,* "Darwinism."

of this theory to the results of biological research, must *in the first place,* be branded as *unscientific*;[1] for it mistakes sensation for spiritual life, and instinct for intelligence, thus being diametrically at variance with the principles of critical psychology. *Secondly,* its assertion, that the brute is gifted with reason and consciousness of duty as well as man, although in a different degree, *is an evident falsehood,* which is given the lie by the actual biological facts. But this popular psychology is not only unscientific and untruthful; it is far worse. To be candid, it is *demoralizing* and fraught with moral danger to the human social order. Hence we must do more than merely shrug our shoulders in contemptuous pity, we must take a decided stand *against it* and *combat* it with all our might.

By denying the existence of the essential difference between animal and human psychic faculties, this psychology not only raises the brute to the level of man, but degrades man to the level of the brute. Would to God that this were done in theory only; but, alas, the practical consequence of this false theory is the *demoralization and brutalization* of man. This is the goal aimed at by those books and pamphlets,

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[1]) Let me once more protest, as I have already done in Chap. I of "Instinct and Intelligence in the Animal Kingdom," that there is no wish on my part to identify the scientific representatives of our modern zoological psychology with the champions of animal intelligence like Brehm, Buechner, etc. This would be an injustice to very many sober-minded naturalists, who condemn just as we do the humanization of the animal. Nor do we in any manner intend to pass judgment on the personal motives of Brehm, Buechner and other defenders of animal intelligence and animal morality, but we only judge of their writings. This remark is added here expressly to avoid misunderstandings.

which describe the sexual impulse of the brute as essentially the same as human conjugal love, and the care of the young among animals as essentially identical with parental love in man. Such men as Alf. Brehm and L. Buechner were not ashamed to come forward as "apostles of free love" and to decry as antiquated and ridiculous the moral bounds established for man by reason and divine law. With them the humanization of the brute, consciously or unconsciously, aims at degrading man so far as to make him cast off his reasonable nature and to follow without reserve the sensual inclinations, which he has in common with the unreasonable brute. On this account they deny the difference between sensitive and spiritual faculties, between the animal soul and the human spirit. Hence we do not consider it too harsh a judgment to say: *Those, who humanize the animal, not only trifle with scientific psychology, but they also drag into the mire the dignity of man.* Every well-meaning naturalist, therefore, ought resolutely to oppose these unprincipled doings of so-called popular psychology.

Now-a-days, there is, and rightly so, a widespread agitation against the use of alcohol and other drugs injurious to the nervous system, because the bodily and spiritual welfare of humanity is endangered. But to counteract the ravages of spiritual venoms, which under the glittering name of modern science are spread through all classes of society, little or nothing is done. If the moral principles of Brehm and Buechner should later on become the common property of humanity, then the society of the future from the highest to the

lowest, would resemble a herd of unreasonable animals, whose "spiritual life" would consist in the unbridled gratification of the meanest lusts and passions. Hence our concluding appeal: *Do away with all books, pamphlets and periodicals, whose only purpose is to raise the brute to the level of man!*